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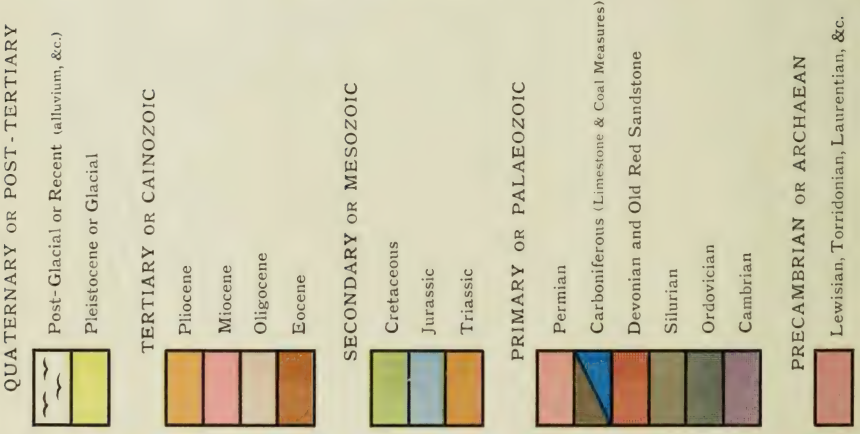
Plate I

THE GEOLOGICAL RECORD

OR ORDER OF SUCCESSION OF THE STRATIFIED FORMATIONS OF THE EARTH'S CRUST.



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PREFACE.

The importance now attaching to the technology of petroleum may be held to justify the publication of a handy book of reference for the use of prospectors, geologists, engineers, and chemists. Much of the information given may also be found of value to those whose duties in connection with the industry are of a purely administrative or commercial character.

The late Mr Leonard V. Dalton, B.Sc.Lond., F.G.S., gave the authors much help in the writing of Part II., Geological.

The authors are indebted to Mr W. H. Dalton, F.G.S., F.C.S., formerly of H.M. Geological Survey, for assistance in the correction of proofs.

The publishers have carried out their share of the undertaking with the liberality and efficiency which have so largely conduced to the high reputation of the technical works issued by them.

B. R.
A. W. E.

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GENERAL INFORMATION ABOUT PETROLEUM.

DEFINITION OF PETROLEUM.

Petroleum, or bitumen, is the generic name given to hydrocarbon compounds occurring in Nature. These substances may be either solid, liquid, or gaseous. The solid kinds are known as *asphalt* or *ozokerite*, the liquid as *mineral oil* or *petroleum*, and the gaseous as *natural gas*.

In addition to these common appellations, there are many terms which have been applied at different times to crude bitumens, which are given in the list below. Some of these names are now practically obsolete, and others have merely a local significance; the foreign names for petroleum will be found on p. 371.

NAMES GIVEN TO VARIOUS FORMS OF BITUMEN.

Albertite.	Fichtelite.	Ozokerite.
Anthraxolite.	Gilsonite.	Parianite.
Asphalt.	Grahamite.	Pissasphaltum.
Barbados Tar.	Hatchettite.	Pisselaeum.
Brea.	Idrialine.	Rangoon Oil.
Carabe.	Impsonite.	Rock Oil.
Coal Oil.	Maltha.	St. Quirinus' Oil.
Dopplerite.	Manjak.	Seneca Oil.
Earth Balsam.	Mumia.	Trinidad Pitch.
Earth Oil.	Naphtha.	Uintaite.
Elaterite.	Oleum Medeae.	Wurzilite.

THE ORIGIN OF PETROLEUM.

Speaking generally, it may be said that the best authorities agree in considering the greater part of the petroleum in the earth's crust to be the result of the decomposition of the remains of marine plants and animals (*i.e.* sea-weeds, shell-fish, etc.), and of the fat-containing parts (seeds, etc.) of land vegetation.

Bacteria probably first decompose the nitrogenous materials into gases and so remove them; then the remaining fatty matters gradually break up into bitumen.

The great number of the conflicting theories which have been advanced to account for the origin of petroleum is due, in part at least, to the variety of conditions under which mineral oil has been met with; so that an hypothesis based on observations in one particular district may fail to meet the case of another. It may be said that the theory given above represents the view of those who, by examining the character and modes of occurrence of oils in various parts of the world, have been enabled to formulate a general hypothesis which covers all but abnormal cases.

OCCURRENCE OF PETROLEUM IN THE EARTH'S CRUST.

The petroleum-forming materials having been buried in the sediments of the ocean floor, water, oil, and gas may be supposed ultimately to accumulate one above the other in the porous strata, when impervious rocks above and below prevent their escape (fig. 1). When in course of time the deposits are consolidated and folded, as in fig. 2, the three fluids are forced to take up new positions, as shown.

In actual practice the gas is more often found to be in solution in the oil than at a separate horizon, but

occasionally there is more or less complete separation. In either case the gas is likely to be under considerable pressure, and when this occurs *flowing wells*, *gushers*, or *spouters* are obtained.

Where the porous strata reach the surface, *i.e. outcrop*, water can enter, and the oil floating on the heavier liquid is gradually forced out, forming *seepages* (see fig. 2). It

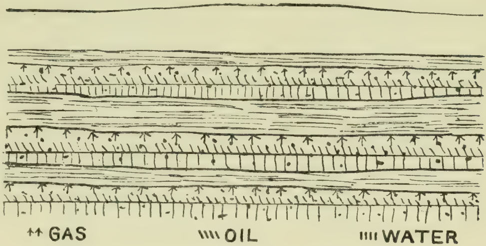


FIG. 1.—Sediments in original position, with oil, water, and gas.

is evident that the oil is only likely to be found in quantity in an oil-bearing stratum where there is adequate protection from influx of surface water. This protection is adequately supplied by an anticlinal fold, where the water in the flanking synclinals effectively traps the oil (see fig. 2). Hence it follows that the majority of the oil-fields of the world are situated on anticlinal folds, and this structure is considered the most favourable which can be met with in prospecting.

In fig. 3 an example is shown of another type of favourable structure known as *lenticular*, where a lens-shaped mass of porous rock is enclosed in impervious strata, so that, even though there is no anticline, the oil and gas cannot escape.

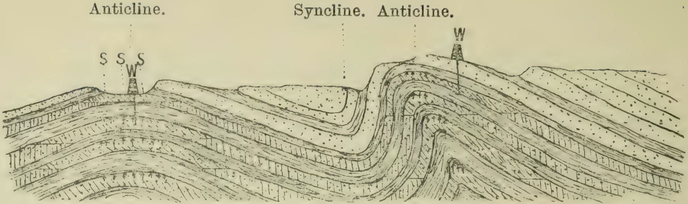


FIG. 2.—Seepages of petroleum (S S S); oil-wells (W W).

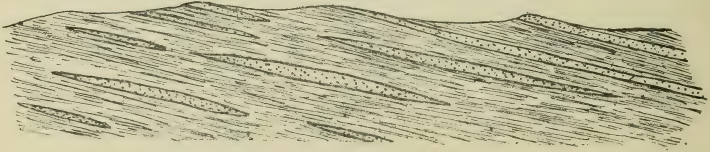


FIG. 3.—Lenticular structure.

GEOGRAPHICAL DISTRIBUTION OF PETROLEUM, ASPHALT, AND NATURAL GAS.

(*See* Maps 1 to 8, in pocket.)

BRITISH EMPIRE.

United Kingdom.

The United Kingdom is not entirely devoid of petroleum, as during the past twenty-five years small quantities, amounting to only a few tons, have been occasionally obtained, chiefly in North Staffordshire, Yorkshire, Dumbartonshire, and recently in Nottinghamshire.

Limited quantities of natural gas have also been obtained at Heathfield in Sussex. The gas has been used for lighting Heathfield railway station, and by a local gas company.

Barbados.

In 1911 "manjak," a glossy asphalt, was being raised from two mines.

Petroleum also occurs in the island.

British Borneo.

In Brunei heavy petroleum has been found in the coal-mine of the Raja of Sarawak. Petroleum also occurs in Sarawak.

British Guiana.

Prospecting for oil is reported to have been carried out in 1911.

Canada.

The oil produced in Canada is mainly derived from the Ontario peninsula, where the Petrolea oil-field has been worked for over fifty years, but the output is gradually diminishing.

The newer districts in Kent county also show a diminution of production.

Recently oil has been found in the white Medina sandstone in commercial quantity in the township of Onondaga, near Brantford.

Oil exists in the Gaspé peninsula.

Attention is now being directed to the exploration of the petroliferous territory of Calgary, Alberta.

Considerable quantities of natural gas are also obtained in Essex, Haldimand, Kent, and Welland counties, Ontario · in the neighbourhood of Medicine Hat and in Bow Island, Alberta.

Recently, fields producing natural gas and a certain amount of mineral oil have been discovered in New Brunswick, where albertite was mined for many years. Petroleum has also been met with in Nova Scotia.

Gold Coast.

Liquid bitumen has been found at Bonyere, and some drilling for petroleum has been carried out near Half Assinie.

India.

The most important oil-field in India is that of Yenangyaung in Burma. In Assam oil has been produced for many years, and a small quantity is obtained in the Punjab.

Newfoundland.

Petroleum has been found at Parsons' Pond, St. Paul's Inlet, and at Port-au-Port on the north-western and western coast of the island.

New Zealand.

Considerable attention has been paid during the last few years to the development of the oil resources of this colony.

Prospecting and drilling for oil have been carried out in the Taranaki, Gisborne, and Lake Brunner districts.

The Taranaki Petroleum Company, which, on 4th May 1911, had produced 268,000 gallons of crude oil, received the first Government bonus of £2500 for the production of 250,000 gallons.

Orange Free State.

Numerous indications of petroleum are reported to exist in various parts of the colony.

Papua.

Petroleum is reported to have been found at the Gira gold-field, and also on the Vailala River, in the Gulf division. In addition to these occurrences, emanations of gas and seepages of oil are stated to have been met with over an area of about 900 square miles.

Southern Nigeria.

Bitumen occurs at Ijebu, Errimu Hill, Mafaoku, and the Errigu valley in the Western province, and borings have met with liquid petroleum.

Trinidad.

Manjak is worked at the Vistabella mine in the vicinity of San Fernando.

Asphalt is largely obtained from the Pitch Lake, and small quantities are excavated at La Brea village. According to a recent survey the lake has an area of 137 acres. The asphalt from the lake consists roughly of 30 per cent. of water, 25 per cent. of fine clay and sand, and 45 per cent. of bitumen.

A large number of successful wells have been sunk for oil, and development work is being carried on at Guapo and Brighton on the Gulf of Paria, and at Guayaguayare.

FOREIGN COUNTRIES.

ALGERIA.

Petroleum is known to occur at many points in Oran, and some drilling has been carried out.

ARGENTINA.

Oil has been found at Comodoro Rivadavia, and in the provinces of Salta and Jujuy in the north of the republic.

AUSTRIA-HUNGARY.

Petroleum is produced at a number of places in Galicia, the most important field being at present that of Tustanowice-Boryslaw, near the town of Drohobycz.

Natural gas and petroleum are obtained in Hungary, but the fields have not yet been extensively developed.

Asphalt and mineral oil are known to occur in Bosnia and Herzegovina.

BOLIVIA.

Petroleum springs exist in the mountainous districts, but no development has yet taken place.

BORNEO. *See* DUTCH EAST INDIES.

CHILE.

The petroleum indications of the Chilean coast have not yet led to any development.

CHINA.

Mineral oil has been found in the brine-wells of the province of Szechuan and elsewhere. Drilling operations are in progress.

Colombia.

Widespread indications of oil are known to occur on the coast and along the Magdalena valley.

Cuba.

Asphalt is mined in the provinces of Pinar del Rio and Habana.

Dutch East Indies.

The oil-fields of Borneo are situated in the sultanate of Kutei, and elsewhere on the east coast. In Java oil-fields have been developed at many points, and on the east side of Sumatra there are the well-known fields of Atjeh, Langkat, and Palembang.

Ecuador.

Undeveloped deposits of petroleum are known to exist at several points in Ecuador.

Egypt.

Oil-fields have recently been developed near Jemsa and Jebel Zeit, and drilling is in progress in the peninsula of Sinai.

Formosa.

The oil-field of Byoritsu has been developed in the north of Formosa, and exploratory drilling is being carried on elsewhere in the island.

France. *See* Ivory Coast, Madagascar, and New Caledonia.

German Empire.

Petroleum is produced in Alsace, Bavaria, and Prussia (Hanover), and the well known Limmer asphalt comes from the neighbourhood of Hanover.

Holland. *See* Dutch East Indies.

Honduras.

Petroleum is said to have been found in several parts of the country.

Italy.

Bituminous limestone is extensively quarried at Ragusa in Sicily, and asphalt in Emilia, where there are also petroleum and natural gas wells. In 1911 the output of petroleum was mainly obtained from wells in the provinces of Parma and Piacenza.

Ivory Coast.

Two permits were granted for the right to search for petroleum in 1911.

Japan.

Oil-fields are widely distributed in the Empire, the belt extending from Sakhalin in the north along the west coast of the various islands to Totomi in the south.

Madagascar.

The Madagascar Oil Development Company is reported to have found a thick oil at 530 feet in a well sunk in the Sakalava valley, seven or eight miles south-east of Folokara.

Mexico.

Very large quantities of petroleum are being obtained in the northern part of the state of Vera Cruz and in adjoining states, as well as in the isthmus of Tehuantepec.

Morocco.

Oil has been discovered (1) near Ulad Aissa, (2) near Sherarda, and (3) at Ain Feriba in the province of Sherarda.

New Caledonia.

Oil is said to occur in this island on the north-west coast.

New Guinea.

Petroleum has been met with on both sides of the island in Dutch territory (*see* Papua).

Nicaragua.

The British Consul at Managua states that oil has been found in the republic.

Panama.

Petroleum is stated to have been found in the province of Los Santos.

Persia.

A wide area of petroliferous territory is known about the head of the Persian Gulf, extending northwards to the Turco-Persian frontier. Borings at Tchiah-Sourkh met with favourable results. The existing oil-fields are in the province of Kermanshah.

Peru.

The oil-fields of Peru are situated on the north-west coast and inland on the west shore of Lake Titicaca, near the Bolivian frontier.

Philippine Islands.

Petroleum and natural gas occur in Cebu, Panay, Guimaras, Mindanas, and Leyte.

Portugal.

Asphalt and petroleum are known to occur north of Lisbon.

Portuguese Nyassaland.

Bitumen occurs on the coast near the river Rovuma.

Portuguese West Africa.

Asphalt and petroleum occur near Dande, Libollo, and Musserra, and elsewhere in Angola.

Rumania.

The principal oil-fields are in the Prahova, Dambovitza, Buzeu, and Bacau districts.

Russia.

The principal centres of production of petroleum are Baku, Grozni, and Maikop in the Caucasus, but oil also occurs elsewhere in the Caucasus, in the Taman Peninsula and near Kertch in the Crimea. Extensive deposits are believed to exist on the river Ukhta in Archangel, and in Nova Zembla, and recently fields have been developed at the north-eastern end of the Caspian; also on Tcheleken Island and in Ferghana. The northern part of Sakhalin possesses petroleum springs.

Santo Domingo.

Petroleum is found in the province of Azua.

Siam.

Oil is obtained from dug pits in Muang Fang, and is stated to occur elsewhere in Siam.

Spain.

Drilling for oil is in progress near Cadiz, and asphalt rock is extensively mined in northern Spain.

Switzerland.

The bituminous limestone of the Val de Travers is extensively mined and exported.

Timor.

Indications of petroleum have been met with at several points in the Portuguese portion of the island of Timor.

Turkey.

The Mesopotamian oil-fields may be regarded as an extension of the Persian deposits already referred to.

Asphalt is mined at Selenitza, and large quantities occur round the Red Sea and in the Jordan valley. Oil has been found on the north coast of the Sea of Marmora, and it occurs in northern Palestine, as well as in the islands of the Red Sea.

United States.

The principal oil-producing states are California, Oklahoma, Illinois, Texas, Louisiana, Ohio, Pennsylvania, West Virginia, Indiana, Kansas, Kentucky, and New York.

Venezuela.

Asphalt is mined in the states of Zulia and Sucre, and petroleum indications are widespread.

PROSPECTING FOR PETROLEUM.

Surface Indications.

Although not a few of the oil-fields of the world date their history from the chance discovery of oil in borings made for other purposes, in the normal way the attention of the prospector is first attracted to the district by the presence of surface indications of petroleum.

These indications are of various kinds, and the most important are the following :—

Seepages.—The most common form of surface show is the actual spring or seepage of oil. This is often made conspicuous by a more or less extensive deposit of asphalt, resulting from the evaporation of the lighter parts of the petroleum and the oxidation of the residue.

Asphalt Deposits.—Occasionally the source of oil becomes clogged, and a mass of hardened asphalt alone remains to mark the site of the former seepage.

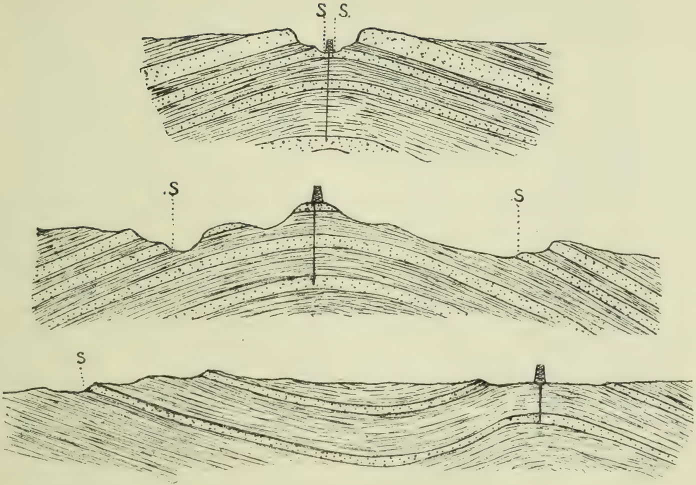
Gas Bubbles.—Bubbles of inflammable gas rising in a pool or stream are often, but not always, a sign of the presence of petroleum. True oil-gas is generally accompanied by iridescent films of petroleum.

Oil-films on Water.—Occasionally, even where no gas is present, iridescent films of oil are found on the surface of water. The films formed by compounds of iron are often very similar in colouring, but these break up into angular fragments when disturbed.

Mud-volcanoes.—In some oil-fields the natural gas has forced its way to the surface through fissures in soft clay strata, the materials of which are thus carried up, accompanied by water, to form "mud-volcanoes," as in Burma, Trinidad, the Caucasus, and elsewhere.

Significance of Surface Indications.

The mistake is frequently made by inexperienced observers of extolling or making light of a possible oil-field in accordance with the extent of the seepages or other surface indications. It may be said at once that the sole value of a seepage in the majority of cases is to show that there is, or has been, oil in the strata of the district in which it occurs. An equally common error is that of supposing that the neighbourhood of a spring of oil is the best site upon which to locate a well. This may or may not be the case, but the true relationship between



FIGS. 4, 5, 6.—Diagrams to show relation between seepages (S) and deep-seated oil.

the oil at the surface and that which may be obtained in quantity by drilling is made clear by the diagrams, figs. 4, 5, and 6.

In fig. 4, while the best site for a well would be in the immediate neighbourhood of the seepages, the oil which such a well would obtain is from a different stratum, and may vary greatly in character from that of the seepage. In fig. 5 the best site for a well is at some distance from the seepages, and again the oil is from a different stratum. In fig. 6 the well would be a very considerable distance from the seepages, but the oil met with in the boring would be in the same stratum as that producing the surface show.

The dip of the strata near the seepage should therefore be observed by the prospector, and a rough map showing the position of the outcrops of strata with their dips is also desirable before any deductions are drawn from the mere presence of surface indications. In making these observations the instruments enumerated on p. 20 will be found useful.

SYSTEMATIC TESTING OF NEW TERRITORY.

New territory is here intended to include all lands believed for adequate reasons to be oil-bearing, but such as have not previously been tested with the steam-drill. Lands on which shallow hand-drilled or hand-dug wells exist are included in the term, even though such properties may be deemed to have been proved to a certain extent.

It may be observed that the terms "shallow," "moderate," and "deep" are often used with varying significance by different writers. In the authors' practice, for general application, the following depths correspond to the three terms:—

Shallow, under 1000 feet.
Moderate, 1000 to 2500 feet.
Deep, 2500 feet and upwards.

Necessarily, however, local conditions modify the signification of the terms. For instance, in a field where the majority of the wells are about 500 feet deep, a boring of 950 feet, though not deep in a general sense, is a relatively deep well for that particular field.

Selecting the Site.

In choosing the location for a test-well two main objects are kept in view :—

(1) To pierce any known or probably occurring petroliferous stratum at the best point to ensure a productive well.
(2) To penetrate the utmost possible thickness of unknown strata, so that the well may not be rendered useless by failing to reach a deep-seated oil-sand.

In the majority of cases practically nothing is known of the character of the strata beneath the surface, and it is therefore usual to adopt the second procedure. A reference to figs. 6 and 14 will show that on a normal anticline the least possible thickness of outcropping beds (*i.e.* known strata) will be passed through by a boring on the crest of an anticline, and therefore such a well will be able to pierce the greatest thickness of unknown strata. Hence it is that test-wells are so frequently located on the crest or axis of anticlines. If the fold is asymmetrical (see fig. 2), or if the structure of the field is monoclinal or terrace (figs. 11 and 12), the selection of sites for test-wells becomes more difficult, many factors having to be taken into consideration.

Drilling Test-Wells.

Assuming the site for the boring to have been selected with due regard to accessibility as well as to the

geological structure of the ground, the efficacy or otherwise of the test will depend entirely upon the way in which the work is carried out.

A careful record should be kept, with samples of all strata passed through, and the depths at which rock changes are encountered. Every show of oil and water should be noted, and all oil should be tested as to quantity. Finally, care should be taken to avoid, as far as possible, the flooding of small oil-sands by water from a higher level, even though the productivity of these is not considered sufficient to pay at the commencement. If these points are attended to, it may be anticipated that the information obtained from the well will be at least commensurate with the cost of drilling. The carelessness or ignorance of drillers has been the cause of the failure of many promising enterprises, and it is for those in charge to see that the information indicated above is duly forthcoming, and to insist that due care is exercised in regard to testing of oil-sands, prevention of influx of water, etc.

As regards the value of sands of small productivity, it may be noted that the average yield per well in the whole of the United States was only 3·3 barrels daily for the year 1912.

Instruments useful to an Oil Prospector.

Geological Hammer.—Some form of geological hammer or small pick is essential to the prospector; and he should be provided with *sample boxes* or *bags* for pieces of rock, asphalt, etc., collected. *Small tin cans*, each having a capacity of about one pint, are useful for containing samples of crude oil.

Clinometer.—For measuring the angle of dip of inclined strata. The hinged "clinometer rule" has a small compass for taking the direction of the dip. Price from £1, 1s. to £3, 3s.

Compass.—Any good compass will serve for rough operations, but a prismatic is the most useful form for making sketch-maps, etc. Prices range from 5s. to £7, 7s.

Geological Compass, Mine Transit, etc.—There are several forms of instrument combining the clinometer with a prismatic compass, thus reducing the number of articles to be carried by the prospector. These vary in price from 12s. to £4, 4s.

Measuring Tape.—An ordinary woven tape in leather case is sufficient for the rough land-surveying required, the prices ranging from 4s. to 14s. A *Pedometer* might be found useful, and a simple form is obtainable at 15s.

*Aneroid Barometer.**—For ascertaining relative levels of the country examined. Prices from £1 to £8, 10s.

Watch-sized aneroids, with a range of 5000 feet, and indicating differences of 10 feet, can be purchased for from £3, 3s. to £3, 10s.

Abney Level.—This instrument serves for ascertaining heights of hills with fair accuracy, the prices ranging from £1, 17s. 6d. to £3, 3s.

Theodolette.—This instrument (price £8, 8s.) is practically a prismatic compass fitted with levels, a dial for finding the heights of objects, etc., and a telescope for accurate observation at a distance.

Theodolite.—For very accurate or more elaborate surveying, a good theodolite is requisite, but will probably be found unnecessary by the prospector. Prices range from £20 to £40.

Good *photographs* of the district in which oil seepages occur will convey a more accurate idea of the type of country and the configuration of the land than any description ; a camera may therefore be considered as a desirable instrument for an oil prospector.

* See also Aneroid Barometer, p. 366.

PARTICULARS REQUIRED IN ORDER TO FORM A PRELIMINARY OPINION OF OIL PROPERTIES.

With a view to obtaining concise particulars of oil properties, in order that a preliminary opinion may be formed as to their character and value, information should be furnished on the following points :—

1. Name of field in which property is situated.
2. Situation of property in field.
3. Name of nearest railway point, with distance and direction.
4. Distance from nearest or most convenient shipping point by water.
5. Area of property.
6. Title : freehold, or leasehold, etc.
7. Terms of tenure.
8. Drilling obligations.
9. Amount of royalty.
10. Rent payable.
11. Whether developed or undeveloped.

If Undeveloped.

12. Particulars and situation of nearest producing properties.
13. What is the general character of the country, *i.e.* hilly or otherwise, number and size of streams, etc. ?
14. What surface indications of petroleum are known in the district, and what are the relative positions of these to each other ?
15. What kind of rocks occur in the district, and which is the most common ?
16. What is the geological structure ? Is any geological map in existence ?

If Developed.

17. Number of wells drilled.
18. Number of producing wells.

19. Number of abandoned wells.
20. Number of dry holes.
21. Number of wells being drilled.
22. Age of oldest well.
23. Average age of completed wells.
24. Age of youngest well.
25. Depth of deepest well to producing level.
26. Depth of shallowest well to producing level.
27. Average depth of finished wells to producing level.
28. Number of additional wells that can still be drilled.
29. Maximum and minimum production per well per diem.
30. Total production per month.
31. Character of the oil. Colour of the oil by transmitted and reflected light, its specific gravity and viscosity at given temperatures, its odour, and whether containing solid hydrocarbons (paraffin) or asphalt, and sulphur.
32. Market price of the oil in the district.
33. Have any contracts been made for the sale of the oil, if so, for what quantity, and at what price, period of delivery, and with whom made ?
34. What system of drilling is employed ?
35. Are the producing wells giving much water ?
36. Is difficulty experienced in shutting off the water ?
37. What are the main difficulties experienced in drilling ?
38. Average time occupied in drilling a well.
39. Cost of drilling a well.
40. Evidence of pressure of oil or gas with the nature (intermittent or continuous) and amount of such pressure.
41. Do the wells flow or are they pumped ?
42. If the wells are not pumped, what means are used for raising the oil ?
43. Do the wells furnish sufficient gas for fuel purposes ?
44. What is the cost of production ?
45. Amount of storage capacity.

46. Distance of nearest pipe-line.
47. What are the pipe-line charges ?
48. Brief general particulars of the plant and buildings.
49. Price and conditions of sale.
50. Is the oil being refined ; if so, where and with what results ?

In all cases a plan of the property should be furnished.

ACQUIRING OIL- AND GAS-LANDS.

The conditions under which drilling rights are acquired on petroliferous lands may generally be dealt with under two headings, viz. (1) where the oil- and gas-rights belong to the State or Crown ; and (2) where these rights are vested in the owner of the land.

In those countries in which the oil- and gas-rights belong wholly or partly to the State, as in Russia, various regulations are in force, which are set forth, as a general rule, in the mining laws of the respective countries. To give these regulations *in extenso* would occupy too much space, and therefore only the salient features of the laws governing the acquisition of oil-lands are specified. For convenience of reference and comparison, the general conditions under which petroliferous territory is obtained from private owners in several countries are also given. The conditions as to the acquisition of oil-lands from private owners vary very widely, although in some instances, notably in some of the states of the American Union, time and custom have led more or less to the adoption of uniform procedure. Typical contracts are given. The purchase outright of producing or undeveloped oil-lands is largely a matter of bargaining. In various parts of the United States it is customary to sell properties on the basis of a specified number of dollars per barrel of daily production, the yield being ascertained, as a rule, by a ten days' gauge. As an example, assuming a property to have an output stated to be 100 barrels per

diem, and the price asked to be \$800 per barrel (the price asked generally includes all plant, etc., on the ground), the production is gauged and \$800 per barrel is paid for each barrel as shown by the average daily yield extending over the period of the gauge mutually agreed upon between the seller and the purchaser. If the gauge showed 90 barrels per day, the purchase price would be \$72,000; if it gave 110 barrels, the price would be \$88,000.

UNITED STATES OF AMERICA.

The leases granted in respect of oil properties are very simple, and the following are the principal conditions generally applicable to the oil-fields of the eastern part of the United States :—

The lease is granted for the sole purpose of "mining and operating for" oil and gas, for laying pipe-lines, and for erecting tanks, buildings, and other structures on the property "for the purpose of taking care of" the products mentioned. The exact situation of the land is described. The lease is generally for a period of ten years, and as long thereafter as oil and gas or either of them is produced by the lessee.

As royalty, the lessee has to deliver to the lessor, free of cost, into the pipe-line to which he may connect his wells, one-tenth, one-eighth, or one-sixth (as the case may be) of all oil "produced and saved" from the leased premises.

In respect of wells in which gas only is produced, the lessee must pay to the lessor \$200 per annum, in advance, for each well, if the gas is being used off the property, and the lessor has the right to the free use of gas to heat and light one dwelling-house situated on the property. The lessor receives from the lessee for gas produced in any oil well, if the gas be used off the premises, \$100 per year for the time during which such gas shall be so used, the payment to be made every three months in advance.

The lessee agrees to " protect all outside lines," that is to say that all wells drilled on the neighbouring lands on the boundaries of the property must be "offset" by drilling corresponding wells on the property leased.

The lessee is bound to commence a well on the land within thirty days from the date of the lease, otherwise the lease becomes null and void.

The minor conditions are: that the lessee must, when requested, bury all pipe-lines below plough depth; that he must pay for all damage to growing crops, caused by drilling; that he has the right to use oil, gas, and water on the leased lands for operations thereon; that he may, at any time, remove all machinery and fixtures placed by him on the property; and that he may draw and remove casing. No well may be drilled nearer than 200 feet to any house or barn situated on the property.

Generally speaking, it may be said that although oil leases are granted for various periods they usually contain a clause that they are for so long thereafter as oil or gas may be produced. Naturally, the oil royalty, the amount payable for gas wells, and the time for the commencement of the first well, together with less important conditions to suit local requirements, vary.

Pennsylvania, West Virginia, and Ohio.

The usual conditions under which oil-land is leased in the States of Pennsylvania, West Virginia, and Ohio are as follows:—

" ...... hereby demise and grant unto the lessee ...., his heirs and assigns, all the oil and gas in and under the following described tract of land, and also the said tract of land for the purpose and with the exclusive right of operating thereon for said oil and gas, together with the right-of-way, the right to lay pipes over, and to use water from said premises, and also the right to erect, or remove at any

time all property placed thereon by the lessee ....
......................"

The situation of the land is then described.

"To have and to hold the same unto the lessee, his heirs and assigns, for the term and period of .... year.. from the date hereof, and as much longer as oil or gas is found in paying quantities thereon, yielding and paying to the lessor the one-eighth part of all the oil produced and saved from the premises, delivered free of expense into tanks or pipe-lines to the lessor's credit, and should any well produce gas in sufficient quantities to justify the marketing, the lessor shall be paid at the rate of........ dollars per year for such well as long as the gas therefrom is sold. In case no well shall be commenced on the above described premises within .... from the date thereof, this lease shall become null and void, and without any further effect whatever unless the lessee shall pay for the delay at the rate of ...... dollars per ...... hereafter, until a well shall be commenced."

Illinois.

Agreement, made and entered into this .... day of .... A.D. 19...., by and between ....
....
of .... County of .... and State of Illinois, part.... of the first part, and ...., parties of the second part.

Witnesseth, That the said part.... of the first part, for and in consideration of the sum of .... dollars in hand, well and truly paid by the said parties of the second part, the receipt of which is hereby acknowledged, and of the covenants and agreements hereinafter contained on the part of the parties of the second part, to be paid, kept, and performed, ha.... granted, demised, leased, and let,

and by these presents do.... grant, demise, lease, and let unto the said second party, its successors or assigns, for the sole and only purpose of mining and operating for oil and gas, and of laying pipe-lines, constructing tanks, buildings, and other structures thereon to take care of said products, all of that certain tract of land situated in the township of ....
County of ...., and State of Illinois, bounded and described as follows, to wit :—

....

....

....

....

....

....

containing .... acres, more or less, hereby releasing and waiving all rights under and by virtue of the Homestead Exemption Laws of the State.

It is agreed that this lease shall remain in force for a term of ten years from this date, and as long thereafter as oil and gas or either of them is produced therefrom by the party of the second part, ... successors or assigns.

In consideration of the premises, the said party of the second part covenants and agrees :—

1st. To deliver to the credit of the first part........, ... heirs or assigns, free of cost, in the pipe-line to which it may connect its wells, the equal one-eighth .... part of all oil produced and saved from the leased premises.

2nd. To pay to the first part .... dollars each year, in advance, for the gas from each well where gas only is found, while the same is being used off the premises ; and the first part.... to have gas free of cost to heat .... stoves in dwelling-house on said premises during the same time.

The party of the second part agrees to complete a well on said premises within .... from the date hereof, or pay at the rate of .... dollars in advance, for each additional .... months such completion is delayed from the time above mentioned for the completion of such well until a well is completed; and it is agreed that the completion of such well shall be and operate as a full liquidation of all rent under this provision during the remainder of the term of this lease.

The party of the second part shall have the right to use oil, gas, and water produced on said land for operation thereon, except water from the wells of the first ....

When requested by first part.... the second party shall bury .... pipe-lines below plough depth.

No well shall be drilled nearer than ...... feet to the house or barn on said premises.

Second party shall pay for damages caused by operation to growing crops on said lands.

The party of the second part shall have the right at any time to remove all machinery and fixtures placed on said premises, including the right to draw and remove casing.

....

....

....

The party of the second part, its successors or assigns, shall have the right at any time, on payment of .... dollars to the part.... of the first part, ... heirs or assigns, to surrender this lease for cancellation, after which all payments or liabilities thereafter to accrue under and by virtue of its terms shall cease and determine.

All covenants and agreements herein set forth between the parties hereto shall extend to their successors, heirs, executors, administrators, or assigns.

Witness the following signatures and seals.
Witness.

....(*Seal*)
....(*Seal*)
....(*Seal*)
....

STATE OF ILLINOIS,
County of .... }

I, ..., in and for said County, in the State aforesaid, do hereby certify that ....
personally known to me to be the same person.... whose name .... subscribed to the foregoing instrument, appeared before me this day in person and acknowledged that ..he.. signed, sealed, and delivered the said instrument as .... free and voluntary act, for the uses and purposes therein set forth, including the release and waiver of the right of homestead.

Given under my hand and .... seal, this .... day of .... A.D. 19....

....
....

OKLAHOMA.

The oil-rights are held, in most cases, under lease, the period of which is for as long as oil and gas are produced in paying quantities. Generally the royalty payable on oil produced is $12\frac{1}{2}$ per cent.

There is a gross revenue tax of 2 per cent. per annum, payable quarterly, on the cash value of all oil sold, *i.e.* the net production. In addition there is a county and state tax of less than 1 per cent., payable yearly, on the value of the plant on the property.

The leases of which illustrations have been given are generally applicable to undeveloped oil-lands, but, as already stated, developed properties are commonly valued on the basis of a certain sum for each barrel of net production per diem.

MEASUREMENT OF LAND IN THE UNITED STATES.

By an Act of Congress passed in 1796 all public lands in the states of the American Union are divided into square townships, so numbered and subdivided that plots of 40 acres can be accurately located by means of a brief description.

In each state a meridian line, known as the **principal meridian,** is accurately located, and is used by the surveyors as a basis for the demarcation of lands. Lines are laid off parallel to this meridian at distances of 6 miles apart, the strips of territory thus formed being known as ranges, numbered east and west from the principal meridian. An E.-W. base line is chosen at right angles to the meridian, and parallel lines are laid down at 6-mile intervals to north and south. The two sets of lines indicated thus divide the territory into squares, the length of each side of which is 6 miles, and the contained area 36 square miles; these squares are the **townships,** any one of which is accurately located by the description "Township x North (or South), Range y East (or West)."

The township is subdivided into thirty-six square **sections** of 1 square mile, or 640 acres each; these are numbered as indicated in fig. 7, beginning in the extreme north-east corner, and proceeding west and east alternately. The section is divided into quarters, and these again into quarters, designated by compass points. For example:—The quarter section marked in Section 10 (fig. 7) would be known as the south-east quarter of

Section 10, while the hatched quarter (40 acres) of the quarter section would be known as the north-west quarter of the south-east quarter section of Section 10.

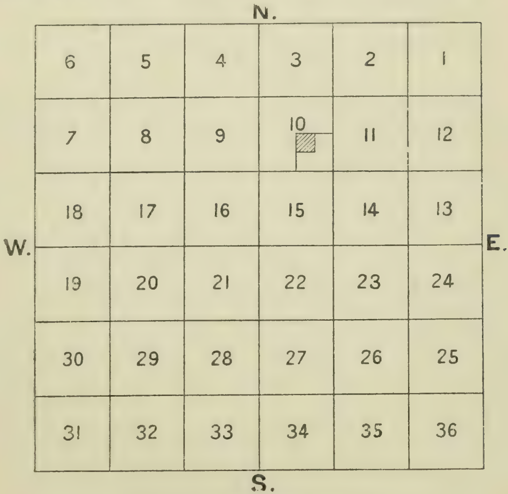


FIG. 7.—United States township.

AUSTRIA (GALICIA).

The acquisition of petroleum-rights in Galicia, from a legal point of view, is a comparatively simple matter. There is an excellent system of land registration in force through which it is easy to ascertain the area of any individual holding, and whether the land in question has any encumbrances or otherwise. Cadastral maps are readily obtained, which, by means of numbers,

clearly indicate all holdings in any district. The numbers on these maps correspond with those entered in what is known as a "ground book," or, in other words, a land register. Any contract, mortgage, lease, etc., relating to any property can be intabulated or registered in the "ground book." In practice, however, the obtaining of oil-rights is frequently a very tedious matter, involving prolonged negotiations through an intermediary. Generally oil-rights are acquired on a royalty basis under lease for a period of twenty-five years, and, as a rule, stipulations are made as to the boring of a certain number of wells. The royalties payable vary considerably, and range from as low as 4 or 5 per cent. in the case of land leased from peasants, to as high as 25 per cent. or more in other cases. The mining laws governing the petroleum industry in Galicia, which are frequently being amended, are complicated, and, in some instances, harassing. Regulations are in force as to the distance of one well from another, and the distance of wells from dwelling-houses, boilers, and the boundaries of neighbouring properties. There are numerous enactments for the safeguarding of workmen, and specified precautions which have to be taken against fire. Recently a law has been passed giving the workmen engaged in drilling wells an 8-hour shift, and therefore, in order to drill night and day, three drillers, with the necessary helpers, etc., are required. Practically in all other parts of the world only two shifts are employed.

BRITISH GUIANA.

Under the new mining (mineral oil) regulations three kinds of licences are granted in this colony, viz.: (1) For the privilege of exploring, (2) for prospecting purposes, and (3) for development. The control of any organisation developing oil-lands must be in British hands, and licences or leases cannot be transferred without the written permission of the Governor.

EGYPT.

Some of the main features of petroleum prospecting licences and petroleum mining leases granted by the Egyptian Government are set forth below :—

Petroleum Prospecting Licence.

Licences to prospect for petroleum are granted by the Ministry of Finance on the following conditions :—

The application must be accompanied by a payment of twenty-five Egyptian pounds, which procures the preliminary licence, without defined or exclusive rights, to prospect for one year over a rectangular area, of which no side must exceed 2 kilometres in length. Within sixty days the licensee must peg out and beacon his claim, upon which he may demand a Government survey, for the expenses of which a further deposit of twenty-five Egyptian pounds is made. If this Government survey is not completed within six months from the date of the licence, an extension equal to the excess over that period is granted. When the Government survey is completed and the land duly marked out, if no prior rights, etc., are found to be infringed, the licence is approved, and the licensee has for the remainder of his term full and exclusive prospecting rights over the demarcated area. Provided that the subsequent conditions are duly fulfilled, the licence may be renewed for another year on application and payment of twenty-five Egyptian pounds, within fifteen days of expiry.

During the term of the licence active work must be commenced and continued without undue intermission. Sites of borings must be duly notified to the Department of Mines, records and samples must be kept, flows of gas, oil, or water kept under control ; and the operations must be conducted by a technically competent manager.

At any time the licensee may apply for a mining lease for any part or parts of his area up to 100 hectares in

all, the leases to be in rectangles of which no side may be less than 500 metres, while each such lease must include at least one productive well. The leases must be surveyed and marked, and the grant of the lease involves surrender of the prospecting licence over the remaining area.

In demarcating areas acquired for prospecting purposes, certain regulations have to be complied with, and the following particulars have to be given to the mining authorities :—

Form.

Date of pegging........................
Name of agent........................

Form number of the licence.... Number of licence....
Name of licence-holder.................

Statement of the geographical position of the area......
....
The " Location Beacon " consists of...................
and is situated...
The " Direction Beacon " consists of..................
and is situated...
distant from the " Location Beacon " in a...........
................direction.

The "First Corner Beacon" is situated in the same line as the " Direction Beacon " and is.................... distant from the " Location Beacon."

The " Second Corner Beacon " is.................. distant from the " First Corner Beacon " in a direction at right angles to the bearing of the line between the " Location " and " Direction Beacons."

The " Third Corner Beacon " is.................... distant from the " Second Corner Beacon " in a direction parallel to that of the bearing between the " Location " and " Direction Beacons," and is...................

distant from the "Location Beacon" in a . . . . direction.

Sketch Map and Plan of Prospecting Area.

N
↑

(*Signed*) . . . .
(*Signed*) . . . .

Petroleum Mining Lease.

The lessee receives exclusive rights in respect of petroleum for a period of thirty years, paying an annual rental for the same of two and a half Egyptian pounds for each hectare or fraction thereof, together with a $7\frac{1}{2}$ per cent. royalty on all oil raised, unless at the date of the lease there were no producing wells on adjoining territory within 5 kilometres, when the royalty is 5 per cent. only. When the amount of the royalty exceeds the amount due as rent, the lessee is entitled to deduct the latter from the sum payable.

As regards production, the Government reserves the right of pre-emption of such quantity of petroleum as shall not exceed in any year 20 per cent. of the previous year's output, for one-half of which quantity the lessee is to be paid 10 per cent. less than the current or royalty price.

Operations shall be commenced within four months from the date of granting of the lease, and must be continued in a business-like manner. Two drilling rigs of adequate size shall be in use on each lease for twenty years, or until there are five borings to each 10 hectares of ground. The sites of borings are to be notified to the Department of Mines, and correct records with drilling samples are to be kept. All regulations in regard to various safeguards, plugging of abandoned wells, etc., must be carried out, and casing may not be withdrawn

from a well without permission. Parts of the lease may be sublet on certain conditions as regards the assignee.

The lease is renewable for fifteen years if six months' notice is given before the expiry of the first term, but the amount of the royalty may then be increased to a proportion not in excess of 10 per cent.

Rules and Regulations as to Mining.

Regulations issued under the following forms :—

Form I. Coal and Oil Prospecting Licence.
Form II. Petroleum Prospecting Licence.

Note.—Circulars Nos. 1 and 2, issued under the C. and O. Licence, are hereby superseded.

Surface rights.

Art. 1. The land included within an area granted under a prospecting licence is wholly the property of the Government, subject only to the right of the licensee to prospect for certain minerals within that area, and the Government is therefore free to grant or refuse permission for the occupation of such land for any purpose other than that specified in the licence.

Applications to erect temporary structures.

Art. 2. The Government is, however, prepared to consider applications for permission to erect temporary jetties, buildings, or other works, or to make roads, tramways, and pipe-lines, which may be required in undertaking the development of prospecting areas.

Working plans and maps to accompany applications.

Art. 3. All applications for such permission must be accompanied by copies of the Company's working drawings and by a map of the site it is proposed to

occupy, showing the position with reference to boundaries of adjoining holdings, works, rights of way, etc. They should be addressed to the Assistant Inspector of Mines at Jemsa.

Removal of temporary structures.

Art. 4. Permission to erect works according to approved plans will only be given on the express condition that the applicant will not acquire any title to the land so occupied, and that all works and buildings will be removed at any time in case of need on demand by the Government, and without compensation.

Applications to erect temporary structures on "prospecting areas" held by other licensees.

Art. 5. Where permission is desired to erect structures on any part of a prospecting area held by another licensee, the applicant must consult the licensee affected and ascertain whether the proposed structures will interfere with prospecting before submitting his plans in conformity with Article 4. When, for any reason, the licensee objects to the erection of such temporary structures, the Department of Mines will inquire into the validity of such objection, and grant or refuse permission as may seem desirable.

Applications for rights of way.

Art. 6. The Government will not raise any objection to free passage over its lands except in so far as such free passage interferes with the operations of its licensees or the general well-being of the industry ; but, in accordance with Article 3, no tramways, railways, or pipe-lines may be put down except with the written permission of the Government.

Labour returns.

Art. 7. The Licensee shall keep an accurate record of all labour employed, and he shall make a return thereof at the end of each month on the prescribed forms.

Plans.

Art. 8. Licensees, or their managers in Egypt, are required to supply :—

Working plan.

(*a*) An up-to-date copy of the working plan of their areas, on which the position of all boreholes, pits, and other exploratory workings, buildings, and other constructions must be shown, together with all available topographical and geological information.

New boring sites.

(*b*) A plan on the scale of 1:500 of each new boring site and of every structure (see Art. 14) or other borehole or shaft within 50 metres thereof. This plan must be delivered to the Resident Inspector, or his representative, before drilling operations are commenced. It must bear the signature of the manager, with the date; no plan can be recognised unless so signed and dated.

Bore Journals.

(*c*) A Bore Journal, which shall be kept on a form approved or prescribed by the Department of Mines, and which will be regarded as the official record of every operation, of whatever nature, in the life of a well from its commencement to its abandonment, and must be supplied to the Department of

Mines at the expiration of every month.

Very particular attention must be paid to recording the exact position of water-, gas-, or oil-bearing strata.

(*d*) Sectional drawings of boreholes are regarded by the Department of Mines as an integral part of the boring record (Clause (*c*), Art. 8). The licensee shall supply the Department on 1st January and 1st July in each year with sectional drawings of all bores completed within the preceding six months. Such sectional drawings are to be drawn to such scale and such form as shall be approved or prescribed by the Department of Mines. The occurrence of water-, gas-, or oil-bearing strata must be indicated in the sectional drawings.

The commencing diameter of the bore and its various reductions must be shown by a sectional drawing in the Bore Journal, together with the depth to which each diameter extends.

(*e*) The dimensions of each column of casing or lining tubes, with special reference to the position of the foot of each column in the bore, must be shown on the sectional drawing and noted in the Journal.

(*f*) The bore record shall be written up

daily at the office of the representative of the licensee on the prospecting area on which the operations are being conducted.

Numbering of boreholes.

Art. 9. Boreholes, or pits, must be numbered consecutively from one up, and no other designation can be accepted by the Department.

Isolation of water-bearing strata.

Art. 10. The isolation of water-bearing strata in boreholes is considered to be of primary importance, no less to the Government than to others interested in the oil-fields.

The Department of Mines will therefore take an active interest in the operations which are conducted in all boreholes in which water-bearing strata exist, more particularly in those where such strata remain for any reason in open connection with other strata.

Licensees are called upon to co-operate with the Department in this matter by keeping the Resident Inspector informed, and by observing the following regulations in every detail :—

(*a*) Full notes of the methods employed in the operations must be made in the Journal, and full details of the tests employed to ascertain the efficiency of the operations and their results must be given.

(*b*) Any clay, cement, or other material introduced into the borehole must be noted in the Journal and shown in the sectional drawing.

Withdrawal of casing from a borehole.

(c) The withdrawal of casing or lining tubes from a borehole, in which they serve the purpose of isolating any water-bearing stratum, is prohibited unless the written permission of the Department of Mines is first obtained.

Explosives.

Art. 11. The Department requires the manager to give in the Bore Journal a full account in each case of the reasons for the use of explosives in boreholes, with a note of the results obtained.

For the special regulations regarding the care and storage of explosives, see separate circular.

Up-to-date records.

Art. 12. All books and records must be kept up to date and open to inspection at all times by the Department of Mines or its authorised agent.

System of drilling to be reported.

Art. 13. The licensee shall make known to the Department of Mines the system of drilling which he proposes to employ, and shall not use any hydraulic system without the written permission of the Department of Mines.

Distance between boreholes and other structures.

Art. 14. No borehole shall be drilled within 40 metres of another borehole, of the foreshore, of any authorised site, official boundary line, building, tramway, thoroughfare, habitation, furnace, workshop, boiler-house, condenser, or reservoir, nor shall any building or construction be erected or borehole be drilled within 40 metres of an existing well without the written permission of the Department of Mines.

Attention is drawn to the necessity of taking into account the prevailing N. and N.-W. winds in planning and laying out such works, with a view to the prevention of fire.

Precautions to control flows of gas, oil, and water.

Art. 15. Proper precautions for efficiently controlling flows of oil, gas, or water shall be taken, and gate valves or other apparatus for capping the well shall be kept in readiness when a flow is anticipated.

These precautions will not be insisted upon if storage has been provided of a capacity sufficient to deal with any ordinary flow of oil.

Abandonment of boreholes.

Art. 16. All abandoned boreholes must be plugged to the satisfaction of the Department of Mines.

Notice of abandonment of any borehole, with details of the methods and materials to be employed in plugging, must be submitted to the Department fourteen clear working days before it is proposed to carry out the work. If no notice is received from the Department of Mines before the date specified for the commencement of work, it may be considered as sanctioned.

Permission to be obtained for locating boreholes in water.

Art. 17. Before any boring or shaft-sinking is undertaken on the foreshore, on the sea, or in standing water, plans of the proposed structures and an outline of the scheme must be submitted to the Department of Mines for approval.

Full-powered lights.

Art. 18. The licensee or his representative must immediately notify the Resident Inspector of the installation

of any full-powered lights, *i.e.* of approximately of 100 c.p. or over.

Accident returns.

Art. 19. The licensee shall, in all cases of accident which may happen at any time to workmen in his employ, report the same on the prescribed forms immediately to the Department of Mines, and shall further keep an accurate record of the same at the mine or mines.

Company's private regulations.

Art. 20. The licensee shall at any time furnish, upon demand, to the Department of Mines, copies of the private regulations of the licensee, or of any person or Company which for the time being may be acting on his behalf.

Penalty.

Art. 21. Failure to comply with these regulations renders the licence liable to cancellation.

(Signed) R. H. GREAVES,
Chief Inspector of Mines.

GIZA, 24*th October* 1911.

HUNGARY.

Under the new mining law of January 1911, petroleum and other bitumens become the monopoly of the State, although those who had acquired mining claims and carried out serious work prior to that date are still permitted to enjoy their rights subject to certain conditions.

Prospecting licences are therefore no longer granted to private individuals, but the State (acting through the Finance Minister) may transfer its rights in mining claims or leases for oil to companies or individuals subject to the approval of Parliament, the transfer being only for a limited period.

A "Freischurf" (**mining claim**) for petroleum is a circular area, the radius of which is 224 Vienna Klafters, within which search may be made for one year, or for longer, upon payment of an annual tax of 8 kronen.

When oil has been struck, the State (or its nominee, as indicated above) is entitled to acquire definite mining rights for a "field" consisting of 8 **mining leases.** Each lease has an area of 45,438 square metres (428·8 by 106·2), so that the "field" has an area of about 36 hectares.

The party contracting with the State to work such mining claims or leases must advise the Mines Office of the transfer of the rights to himself within fifteen days on pain of annulment. The contract must be such as to secure the best interests of Hungarian industry, and the maximum price to be charged for produce is to be stated.

PERU.

The Peruvian laws relating to the location of oil-claims or "denouncements" are reasonable, the holder's position is clearly defined, and he is adequately protected. After paying the cost of survey and location of a claim there is an annual tax of £3 per "pertenencia" (about 10 acres), the unit of claim. The owner of the mining rights may expropriate such surface land as he may reasonably require for developing the property.

RUMANIA.

The Rumanian mining laws have recently been amended, and, as far as the authors have been able to ascertain, complete particulars have not yet been published.

RUSSIA.

The acquisition of petroleum lands in Russia, in cases where the oil-rights belong to the Crown, is a comparatively easy matter, as it is only necessary to mark the

centre of the mining claim or **zaiavka** with a stone or stake having the date upon it of the staking out of the claim. A mining claim consists of a square, the boundary lines of which run north, south, east, and west, and are each 300 sagenes (700 yards) in length, an area of 90,000 square sagenes (101 acres) being thus enclosed. On payment of the requisite fees the owner of the mining claim secures the right to explore this area for a period of two years from the date of the grant. At the end of that period, provided oil has been discovered, the owner may select from the mining claim what is known as an **otvod** in any part of the claim, provided that the plot selected is rectangular in form and in one complex. An otvod, which has an area of 24,000 square sagenes or 10 desiatines (27 acres) is granted at an annual rental of 10 roubles per desiatine for so long as oil is produced. In the event of the land in which the claim is situated being officially declared as petroliferous, the Government has the right to dispose of the remainder of the claim by auction or otherwise on a basis of either rent or royalty. If the owner of the otvod does not commence work on it within two years from the date on which it was granted, the plot is liable to forfeiture.

In the case of land granted to Cossacks there are certain regulations as to royalties, etc., which vary in different districts.

As elsewhere, the acquisition of oil-rights from private owners or communes is a matter of negotiation. Generally such land is obtained under lease for a period of years, on a royalty basis, or at dead rent merging into royalty, with varying obligations as to drilling wells and the amount of rent payable for surface land occupied by buildings, storage-tanks, wells, etc.

TRINIDAD.

Prospecting licences and leases for petroleum lands are obtained from the Governor of Trinidad.

NATURAL GAS.

The mode of occurrence of natural gas has been indicated sufficiently fully in the preceding pages.

Gas-fields, as distinguished from oil-fields, have been developed hitherto practically only in the New World, and the use of natural gas on a large scale for heating and lighting is confined to Canada and the United States. On many oil-fields, however, natural gas is used on the

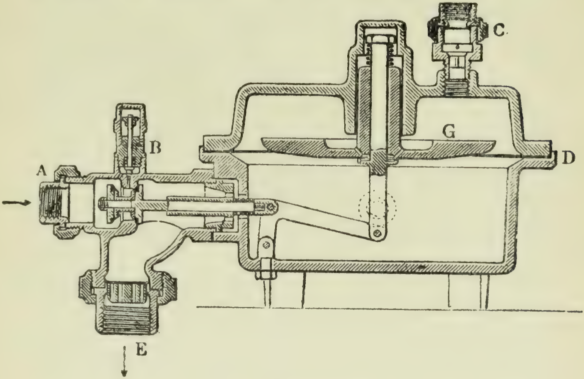


FIG. 8.—Gas regulator.

properties for heating, lighting, and power purposes. If a well or entire field produces only gas, without oil, the product is led directly into mains and delivered to the consumers.

In the United States the pressure is now equalised throughout the service by means of regulators, as shown in fig. 8. The gas enters from the main at A, and

passes to the service-pipe at E, through a piston valve connected with a weight, G, on a diaphragm in a casing, to which the gas has access round the rod of the piston valve. If the pressure be excessive, the valve is wholly closed until the pressure has been reduced, the gas meanwhile escaping through a safety-valve, B. Natural gas is distributed to the consumer in wrought-iron pipes, ranging in diameter from 2 inches up to 20 inches. The initial pressure is sometimes as high as 400 lbs. to the square inch, but usually reaches from 200 to 300 lbs. where the diameter is not over 10 inches. Riveted wrought-iron pipes, 3 feet in diameter, are also used. The most common method of distribution in cities and towns is by a series of pipes from 12 inches down to 2 inches in diameter, usually carrying a pressure of about 4 ounces to the square inch. To these pipes the service-pipes leading into the houses of the consumers are connected. This low pressure is fed at numerous points by a series of automatic regulators connected by lines which carry a pressure usually ranging from 20 to 50 lbs. to the square inch. Another system of distribution is that of placing inside or near each house a reducing-valve connected to a smaller pipe carrying a higher pressure.

OIL-SHALE.

Oil-shale is a dark grey or black substance, having a laminated or horny fracture. Its specific gravity is about 1·75, and 20 cubic feet of it weigh rather less than a ton. True oil-shales have not, as a rule, any bituminous smell, but they yield on distillation varying amounts of an oil resembling crude petroleum, the quantity obtained being occasionally more than 100 gallons per ton.

Microscopic examination of the substance shows that it is mainly composed of marine plants with some animal remains, mixed with fine clay particles. It may thus be looked upon as a coal of marine origin, in contra-

distinction to the ordinary coals made up of the remains of land plants.

Many varieties of shale have been distilled from time to time, ranging from true oil-shale having no bituminous odour to shales which are saturated with petroleum but have none of the normal characteristics of oil-shale.

In addition to the oil, a large quantity of ammoniacal liquor is obtained in the distillation. The crude **shale-oil,** as it is termed, is generally of a dark green colour, and contains a large percentage of paraffin wax. It is refined in essentially the same way as ordinary petroleum.

On destructive distillation the Scottish shales yield on the average 23 gallons of oil to the ton. Some of the material is rich in oil and poor in respect of the yield of sulphate of ammonia, and in other cases the reverse is the case.

It would appear that the companies in Scotland having shale giving a high percentage of sulphate of ammonia, the average yield of which in 1910 is stated to have been 45 lbs. per ton of shale, occupy the most favourable position. The oil-shale industry of Scotland has passed through many vicissitudes, but the companies now working are carrying on a lucrative business of considerable local importance.

In his treatise on mineral oils, Mr. Iltyd I. Redwood states that the specific gravity of Scottish shales does not vary very greatly, and usually ranges between 1·713 and 1·877. The specific gravity of the Torbanehill mineral was 1·224.

The average composition of a good shale is as follows:—

Moisture (at 240° F.)	2·67	per cent. by weight.
Volatile matter	24·31	,, ,, ,, ,,
"Fixed" carbon .	12·50	,, ,, ,, ,,
Ash	60·50	,, ,, ,, ,,
Total . .	99·98	

GEOGRAPHICAL DISTRIBUTION OF OIL-SHALE.

BRITISH EMPIRE.

United Kingdom.

The bulk of the oil-shale raised in the United Kingdom is obtained in Linlithgowshire, but a considerable quantity is also mined in Edinburghshire, and smaller amounts in Lanarkshire and Sutherlandshire. In recent years small quantities have been mined in Flintshire, but none was obtained there in 1909 or 1910.

In Lanarkshire some of the shale is used in making gas.

Deposits of bituminous shales exist in Dorsetshire, notably at Kimmeridge, Ringstead, and Portesham.

Australia.

Kerosene-shale is extensively mined in New South Wales, north-west of Sydney; similar shales are also reported to be found in Queensland.

Canada.

Oil-shale is said to have been found at Macadam's Lake, on the north side of East Bay, Cape Breton, Nova Scotia; and numerous seams giving a large yield of oil are known to occur in New Brunswick.

Newfoundland.

Oil-shale has recently been found on the west coast of the island, near Deer Lake.

New Zealand.

Oil-shale occurs at Awatere, near Mongonui, and Waimate, Bay of Islands, Auckland, and is reported to have been found on D'Urville Island; in Otago; and on the Chatham Islands.

Tasmania.

In 1910 the production by distillation of crude oil from shale was commenced at Latrobe. Oil-shale deposits occur between Latrobe and Railton, at Nook Road, and other places.

FOREIGN COUNTRIES.

Brazil.

Oil-shales occur over a wide area in the north-eastern part of Brazil, southward of the mouth of the Amazon, the deposits being seen at different points on the coast as far south as Porto Alegre.

France.

Bituminous shale is mined in four departments—Saône-et-Loire, Allier, Puy-de-Dôme, and Basses Alpes. The principal deposits are those of Autun (Saône-et-Loire) and Buxière-les-Mines (Allier).

Germany.

The earthy lignites of Saxony are extensively mined and distilled for the production of mineral oils and paraffin.

Servia.

Deposits of oil-shale are known to exist in Servia.

Spain.

Extensive deposits of oil-shale occur in the Ronda district, and bituminous shales have been mined northwestward of Barcelona.

PART II.

GEOLOGICAL.

DEFINITIONS OF SIMPLE GEOLOGICAL TERMS.

Sedimentary Rock.—A rock formed in the first place by deposition of sediment (sand, mud, lime, etc.) under water. By far the greater part of the present land surface of the globe has been formed in this way under sea-water.

Examples.—Sandstone, shale, limestone.

Igneous Rock.—A rock which was at some time thrust up from the bowels of the earth in a molten form; afterwards consolidated by cooling in or upon sedimentary deposits.

Examples.—Lava, basalt, granite.

Fossils.—Anything which has been buried beneath the surface of the earth by natural causes or geological agencies, and which bears in its form or chemical composition the evidence that it is of organic origin.

Examples.—The shell or cast of a mollusc, ferns (in coal-shales), bones, leaves.

Geological Age.—Although, owing to movements of the earth's crust, sedimentation (or deposition of sand, mud, etc.) has not proceeded continuously in any one part of the globe since the beginning of time, it has nevertheless always been going on at one point or another. By means of the fossils embedded in the rock it is possible to arrange the deposits of the whole globe in a continuous series, having the most ancient at one end and the most recent (*i.e.* those even now in process of formation) at the other. This series, or "geological record," can be

classified into five main divisions, which are further ranged in systems, and each system in series or formations, and so forth. The systems and larger groups are shown in Plate I. (Frontispiece), and the geological age of a deposit or series of deposits is given broadly or minutely in reference to this arrangement.

Examples.—Silurian, Secondary, Miocene.

Stratification.—The material deposited on the floor of a sea or lake tends to vary in character from time to time, and it is also usual for sedimentation to proceed intermittently. The result is that after some feet or inches

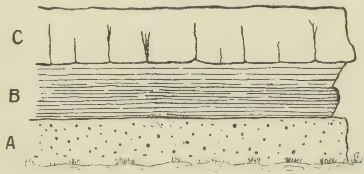


FIG. 9.—Stratification.

of a deposit have been laid down, this is slightly consolidated by the weight of water above, before a further quantity of the same or a different material falls to the bottom. In this way slight partings are formed in the mass, and when after a lapse of time the movements of the earth change the former sea floor to dry land, it is seen that the sediments are arranged in layers. This arrangement is known as stratification, and the layers as *strata.* Each successive *stratum* may of course be of the same material, but sooner or later sandstone will give place to shales or clays, and these possibly to limestones (see fig. 9).

"**Strike**" and "**Dip.**"—Sedimentary deposits are naturally formed with the strata in a practically horizontal position, but the earth-movements which raise

them so as to form land have generally inclined them at varying angles from the horizontal. The angle at which any particular stratum is inclined to the horizontal is known as its *dip*. This angle is measured on the surface of the stratum, generally known as a *bedding-plane*, and at right angles to the horizontal line across this plane, which is known as the *strike* (see fig. 10). The direction of strike of a bed, or of a series of beds, may be the same

FIG. 10.—Strike and Dip.

across a wide stretch of country, but frequently it varies locally, even though the general strike remains the same.

Example.—Strike of bed N.-W. Dip 25° to S.-W.

Geological Structure.—The manner in which the rocks of any given area are tilted, and the relation of one set of deposits to another, determine the geological structure of the district, which may be indicated in general terms as complex, simple, etc., or more particularly in a variety of terms of which the simplest and most important are described below.

Monoclinal.—Where the rocks of a district all dip continuously in the same direction over a wide area, the structure is said to be monoclinal (see fig. 11). A modification of this, known as *terrace structure*, is met with in the Appalachian and Ohio oil-fields, where, though the rocks dip in the same direction, the angle

FIG. 11.—Monoclinal.

FIG. 12.—Terrace structure (A A).

varies so as to produce a kind of underground terrace (see fig. 12).

Faults.—The movements of the earth's crust have not only tilted and folded the rocks, but have fractured them.

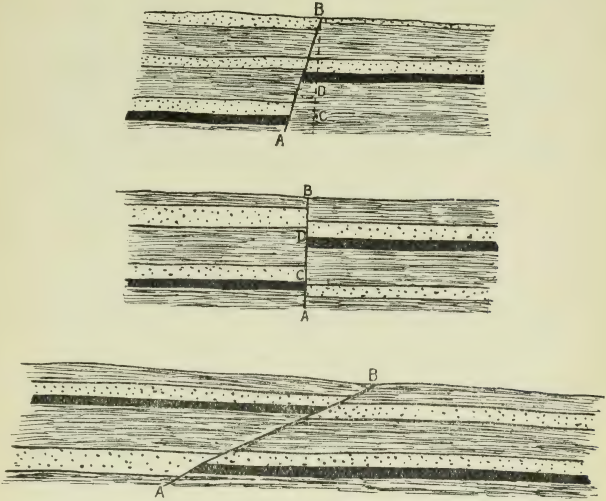


FIG. 13.—Faults (A B).

These dislocations may be simple **fissures**, that is, rents without any vertical displacement of the mass on either side; or faults, that is, rents where one side has been moved relatively to the other. These faults are of various kinds, and the simpler forms are shown in fig. 13.

Anticlines and **Synclines.**—More commonly earth-movements have thrown the strata into a series of folds forming saddles and troughs; these saddles are known as anticlines and the troughs as synclines. The ridges and valleys of the surface do not necessarily or even usually correspond to the saddles and troughs of the rocks, as they have been produced by the wearing action of rain, streams, wind, etc., in the process of *atmospheric denudation* or *erosion*. The middle line of the anticline is termed its *axis* or *crest*, whilst the middle line of the syncline is termed its *axis* (see fig. 14).

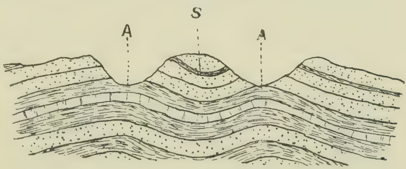


FIG. 14.—Anticlines (A) and Syncline (S).

A **Porous Rock** is one which allows liquids, such as petroleum or water, to pass freely through it.

Examples.—Sandstone, some limestones.

An **Impervious Rock** is one which resists the free passage of liquids.

Examples.—Clay, shale, compact limestone.

IDENTIFICATION OF ROCKS.

Since weathering greatly changes the appearance and character of most rocks, the first step towards the identification of any rock mass or specimen is to secure a freshly broken surface; this may then be examined

with or without a lens, and the general characters observed can be grouped as follows :—

(*a*) Close-grained, dull, without distinct structure.
(*b*) Composed of grains or fragments.
(*c*) Glassy.
(*d*) Crystalline.
(*e*) Foliated.

It is generally possible to assign any given rock to one of these groups, though it may be noted that the more compact varieties of groups (*b*) and (*d*) are not easily differentiated without a lens. Assuming, however, that such difficulties have been overcome, the further identification may be proceeded with as follows :—

(A) Rock Close-Grained, Dull, Without Distinct Structure.

(1) Soft and crumbling, or easily scratched with the knife, if not with the nail ; when breathed upon emits an earthy smell ; does not effervesce with acid ; is dark grey, brown, or blue, sometimes red, yellow, or even white. Probably some clay rock, such as **mudstone, massive shale,** or **fireclay.** If the rock is hard and easily splits up into regular fragments or *laminæ*, it is probably **shale** or **slate.**

(2) Can be scratched with the knife, but not with the finger-nail ; occurs in beds or veins ; is white, yellow, or pink ; does not effervesce with acid. Probably **gypsum.**

(3) Friable and crumbling, soiling the fingers ; white or yellowish ; brisk effervescence with acid. Probably **chalk, marl,** or **soft limestone.**

(4) Can be scratched without difficulty with the knife ; is white, bluish-grey, or perhaps yellow, brown, or black ; brisk effervescence. A **limestone.**

(5) Same hardness as or slightly harder than (4) ; is yellowish, white, or pale brown. It does not effervesce

freely in acid except when powdered, or if hot acid be used. Probably a **dolomitic limestone** (dolomite).

(6) Same hardness as (5); is dark brown to dull black; does not effervesce; occurs in nodules or beds, usually with shale; **clay-ironstone, limonite,** etc.

(7) Heavy dark-coloured rock; not easily scratched with the knife; not effervescing with acid. Probably some variety of close-grained **igneous rock**, for which see group (*d*).

(8) Harder than steel, *i.e.* the knife leaves a metallic streak on the rock; white, reddish, yellowish to brown or black; of horny texture or very finely granular; does not effervesce. Probably **jasper, flint,** or other form of **silica.**

(B) Composed of Grains or Fragments (*i.e.* Clastic).

Volcanic agglomerates, breccias, or **tuffs** are made up of angular fragments, the igneous character of the whole being generally fairly evident. If the grains or fragments are rounded, the rock may be set down as a **sandstone** or **conglomerate** according to the coarseness of the materials.

(C) Glassy.

A fragment of glassy appearance may possibly be quartz, which will be colourless or tinted, red, brown, yellow, etc. A black glassy rock will probably be **obsidian** or other form of **volcanic glass.**

(D) Crystalline.

(1) Can be easily scratched with the knife.

- (*a*) Effervesces briskly with acid. **Limestone.**
- (*b*) The powdered rock effervesces with acid especially when heated. **Dolomite.**
- (*c*) Does not effervesce. Probably some form of crystalline **gypsum** (alabaster) or **anhydrite.**

(2) **Not easily scratched.** Probably igneous.

(*a*) Consists of one mineral only, and of a greenish tinge. An **amphibolite.**

(*b*) Consists of a white mineral (felspar) and of a green mineral which gives the general colour to the rock; the weathered crust effervesces more or less with acid. Probably a "**greenstone,**" **diorite,** or **diabase.**

(*c*) Black and heavy, very finely crystalline; crystalline character often not visible save with microscope; weathers brown. Probably **basalt.**

(*d*) Grey and granular; with white and dark crystals; weathered crust yellowish or brown. Probably a **dolerite.**

(*e*) Fine grained in general with scattered large crystals of felspar. Possibly **andesite.**

(*f*) Compact, very finely crystalline in general; with larger white felspar crystals; hard, weathered crust, white and clayey. Probably **quartz-porphyry** or other **porphyry.**

(*g*) Evenly crystalline, generally grey or red; with clear crystals of quartz. **Granite, syenite,** etc.

(*h*) As (*g*), but with quartz in long lens-shaped masses coated with mica. Possibly a **gneiss** or **schist** (*see below*).

(E) Foliated.

The foliated rocks vary from fine-grained **clay-slates,** through the different varieties of **schist,** showing a more or less crystalline structure, to crystalline **gneisses,** like granites, but distinguished from them by the arrangement of the mineral in layers, often more or less contorted (*foliation*).

SCALE OF HARDNESS FOR ROCKS AND MINERALS.

1. Talc.
2. Gypsum or rock salt.
3. Calcite.
4. Fluorspar.
5. Apatite.
6. Felspar (Orthoclase).
7. Quartz.
8. Topaz.
9. Corundum.
10. Diamond.

TO CALCULATE DEPTH TO A GIVEN HORIZON IN BORING.

(1) If the horizon outcrops (as *ab*, fig. 15),

Let *bc* be the horizontal distance to boring,
abc or *x* the angle of dip.

Then depth of horizon *ab* in boring below the level of the outcrop is *ca*; the value of which is given by the ratio—

$$\frac{ca}{cb} = \tan x$$

$$i.e.\ ca = cb \tan x.$$

Total depth in boring is *ca* + height of boring site above level of outcrop ($= ce$).

$\therefore$ Depth of required horizon in boring is

$$cb \tan x + ce.$$

Example—

Distance of well from outcrop at right angles to strike is 130 feet.

Derrick floor is 25 feet above level of outcrop.

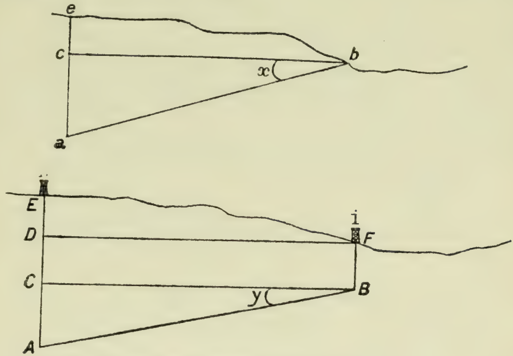
Dip is 30°.

Depth $= 130 \tan 30° + 25 = 130 \times \cdot 5773503 + 25 = 75 + 25 = 100$ feet.

(2) If the required horizon has been met with in a previous boring (as AB, fig. 16).

Let ABC or *y* be the angle of dip from boring i to ii,

this can be calculated from the observed dips by means of the formula on page 64, or in place of the actual distance from i to ii, the length of the perpendicular through either well on the strike line through the other may be used in place of BC with the true angle of dip (see fig. 17).



FIGS. 15 and 16.—Depth of strata in borings.

The total depth of required horizon in boring ii is the sum of—

The increased depth as compared with boring i $=$ AC
The depth in boring i $=$ BF $=$ CD
The difference in level of the two sites $=$ DE
i.e. depth $=$ AC $+$ CD $+$ DE.
AC is given by

$$\frac{AC}{CB} = \tan y \text{ or } AC = CB \tan y$$

$\therefore$ Depth is CB $\tan y$ $+$ CD $+$ DE.

Example—

Depth of horizon in boring i = 1305 feet.
Difference of level between i and ii = 20 feet
Angle and direction of dip = 25° to N. 30° W.
Distance from i to ii = 600 feet.
Direction from i to ii, N.

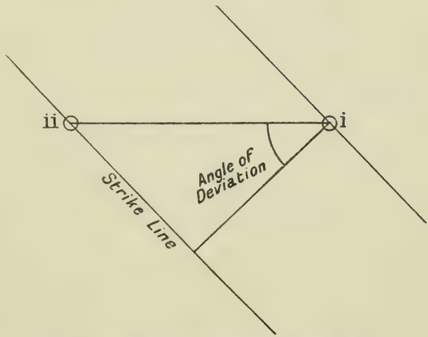


FIG. 17.—Calculation of dip between two wells.

Tangent of angle of dip along line i to ii is given by—
tan apparent = tan 25° cos 30° =
$0{\cdot}4663077 \times 0{\cdot}8660254 = 0{\cdot}403834$.

∴ Angle required is approximately 22°.

$$\begin{aligned}\text{Depth} &= 600 \times {\cdot}403834 + 1305 + 20 \\ &= 242{\cdot}3 + 1305 + 20 \\ &= 1567{\cdot}3 \text{ feet.}\end{aligned}$$

TO FIND THE ANGLE OF DIP FROM THE DEPTHS OF THE SAME HORIZON IN TWO WELLS.

Reverse the preceding formula, thus—

$$\tan ABC = \frac{CA}{CB},$$

this will give the dip *along the line of section between the two wells*; the true dip can be calculated if the strike is known.

Example—

Depth of horizon in boring i . .	= 1360	feet.
" " ii . .	= 1455	"
Distance from i to ii	= 600	"
Difference of level between i and ii	= 25	"

$$CA = 1455 - 25 - 1360 = 70,$$

$$\tan ABC = \frac{70}{600} = 0{\cdot}11\dot{6}.$$

$\therefore$ ABC is approximately 6° 39′.

TO FIND THE APPARENT ANGLE OF DIP ALONG ANY REQUIRED LINE OF SECTION FROM THE FULL DIP AND THE DEVIATION OF ITS DIRECTION FROM THAT OF THE SECTION.

Let ABC be the vertical plane along the full dip.
" DC be the direction of the required section.

Draw BD perpendicular to BC: CE perpendicular to CD and = CA: join DE.

Then ABC is the angle of full dip, EDC is the required angle, BCD is the angle of deviation.

$$\tan ABC = \frac{AC}{CB}, \qquad \tan EDC = \frac{EC}{CD},$$

$$\cos BCD = \frac{BC}{CD}.$$

$$\frac{BC}{CD} = \frac{AC}{CD} \times \frac{BC}{AC} = \frac{AC}{CD} \div \frac{AC}{CB}.$$

$$\therefore \quad \cos \text{deviation} = \frac{\tan ADC}{\tan ABC},$$

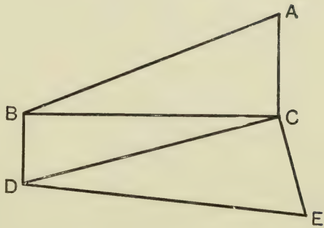


FIG. 18.—Apparent dip.

$$\text{or } \tan EDC = \tan ABC \cos BCD,$$

i.e. tan apparent = tan real cos deviation.

Example—

Angle and direction of full dip 32° to N. 30° W.
Direction of required line of section N. 64° W.
Then tan required angle = tan 32° cos (64° − 30°),
= tan 32° cos 34°,
= 0·6248694 × 0·8290376,
= 0·518040.

∴ Required angle = 27° 23′.

TO FIND THE TRUE ANGLE AND DIRECTION OF DIP FROM TWO APPARENT DIPS.

Let the two observed dips be A and B, and the unknown angles between the directions of these dips and that of the true dip respectively α and β.

Then from the preceding formula—

$$\tan A = \tan \text{real} \cos \alpha,$$
$$\text{and } \tan B = \tan \text{real} \cos \beta.$$

$$\therefore \quad \frac{\tan A}{\tan B} = \frac{\cos \alpha}{\cos \beta}.$$

Whence, by trial, values can be found for α and β; and, $\cos \alpha$ or $\cos \beta$ being known, either of the preceding equations will give the value of tan real.

Example—

Apparent dips observed—

38° to N. 35° W.
30° to N. 40° E.

$$\frac{\tan 38°}{\tan 30°} = \frac{\cos \alpha}{\cos \beta}, \text{ and } \alpha + \beta = 75°.$$

$$\therefore \quad \frac{\cos \alpha}{\cos \beta} = \frac{0{\cdot}7812856}{0{\cdot}5773503} = 1{\cdot}353225.$$

$\therefore$ By trial α is approximately 26° 25′,
and β ,, ,, 48° 35′.

$$\tan \text{real} = \frac{\tan 38°}{\cos 26°\ 25'} = \frac{0{\cdot}7812856}{0{\cdot}8955824} = 0{\cdot}8723556.$$

$\therefore$ True dip is 41° 6′ to N. 8° 35′ W.

TABLE OF DEPTHS AND THICKNESSES.

The depths here given correspond to the lengths of *ca* and CA in figs. 15 and 16; the thicknesses give the number of feet of beds outcropping in the indicated distance at the various angles of dip.

Angle of dip. Degrees.	Horizontal Distances. 100		200		300		400		500	
	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.
1	1·74	1·74	3·49	3·49	5·23	5·23	6·98	6·98	8·72	8·72
2	3·49	3·49	6·98	6·97	10·47	10·47	13·97	13·96	17·46	17·45
3	5·24	5·23	10·48	10·46	15·72	15·70	20·96	20·93	26·20	26·16
4	6·99	6·97	13·98	13·95	20·97	20·92	27·97	27·90	34·96	34·87
5	8·75	8·71	17·59	17·43	26·24	26·14	34·99	34·86	43·74	43·57
6	10·51	10·45	21·02	20·90	31·53	31·36	42·04	41·81	52·55	52·26
7	12·28	12·19	24·55	24·37	36·83	36·56	49·11	48·74	61·39	60·93
8	14·05	13·92	28·10	27·83	42·16	38·75	56·21	55·66	70·27	69·58
9	15·84	15·64	31·67	31·28	47·51	46·93	63·35	62·57	79·19	78·21
10	17·63	17·36	35·26	34·73	52·89	52·09	70·53	69·45	88·16	86·82
11	19·44	19·08	38·87	38·16	58·31	57·24	77·75	76·32	97·19	95·40
12	21·25	20·79	42·51	41·58	63·76	62·37	85·02	83·16	106·27	103·95
13	23·08	22·49	46·17	44·99	69·25	67·48	92·34	89·98	115·43	112·47
14	24·93	24·19	49·86	48·38	74·79	72·57	99·72	96·77	124·66	120·96

Table of Depths and Thicknesses—*continued.*

Angle of dip. Degrees.	Horizontal Distances. 100 Depth.	100 Thick-ness.	200 Depth.	200 Thick-ness.	300 Depth.	300 Thick-ness.	400 Depth.	400 Thick-ness.	500 Depth.	500 Thick-ness.
15	26·79	25·88	53·59	51·76	80·38	77·64	107·17	103·52	133·97	129·40
16	28·67	27·56	57·35	55·12	86·02	82·69	114·69	110·25	143·37	137·81
17	30·57	29·23	61·14	58·47	91·72	87·71	122·29	116·95	152·86	146·18
18	32·49	30·90	64·98	61·80	97·47	92·70	129·96	123·60	162·45	154·50
19	34·43	32·55	68·86	65·11	103·29	97·67	137·73	130·22	172·16	162·73
20	36·39	34·20	72·79	68·40	109·19	102·60	145·59	136·80	181·98	171·01
21	38·38	35·83	76·77	71·67	115·16	107·51	153·54	143·34	191·93	179·18
22	40·40	37·46	80·80	74·92	121·20	112·38	161·61	149·84	202·01	187·30
23	42·44	39·07	84·89	78·14	127·34	117·22	169·79	156·29	212·23	195·36
24	44·52	40·67	89·04	81·34	133·56	122·02	178·09	162·69	222·61	203·36
25	46·63	42·26	93·26	84·52	139·89	126·78	186·52	169·04	233·15	211·30
26	48·77	43·83	97·54	87·67	146·32	131·51	195·09	175·35	243·86	219·18
27	50·95	45·40	101·90	90·80	152·85	136·89	203·81	181·59	254·76	226·99
28	53·17	46·94	106·34	93·89	159·51	140·84	212·68	187·79	265·85	234·73
29	55·43	48·48	110·86	96·96	166·29	145·44	221·72	193·92	277·15	242·40
30	57·73	50·00	115·47	100·00	173·20	150·00	230·94	200·00	288·67	250·00
31	60·08	51·50	120·17	103·00	180·26	154·50	240·34	206·01	300·43	257·51
32	62·48	52·99	124·97	105·98	187·46	158·97	249·94	211·96	312·43	264·95
33	64·94	54·46	129·88	108·92	194·82	163·39	259·76	217·85	324·70	272·31

TABLE OF DEPTHS AND THICKNESSES—*continued.*

Angle of dip. Degrees.	Horizontal Distances.									
	100		200		300		400		500	
	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.
34	67·45	55·92	134·90	111·84	202·35	167·75	269·80	223·67	337·25	279·57
35	70·02	57·35	140·04	114·71	210·06	172·07	280·08	229·43	350·10	286·78
36	72·65	58·78	145·31	117·55	217·96	176·33	290·61	235·11	363·27	293·89
37	75·35	60·18	150·71	120·36	226·06	180·54	301·42	240·72	376·77	300·90
38	78·13	61·56	156·25	123·13	234·38	184·70	312·51	246·26	390·64	307·83
39	80·98	62·93	161·95	125·86	242·93	188·79	323·91	251·73	404·89	314·66
40	83·91	64·28	167·82	128·55	251·72	192·83	335·63	257·11	419·54	321·39
41	86·93	65·60	173 85	131·21	260·78	196·81	347·71	262·42	434·64	328·02
42	90·04	66·91	180·08	133·82	270·12	200·74	360·16	267·65	450·20	334·56
43	93·25	68·20	186·50	136·40	279·75	204·59	373·00	272·79	466·25	340·99
44	96·57	69·46	193·13	138·93	289·70	208·39	386·27	277·86	482·84	347·32
45	100·00	70·71	200·00	141·42	300·00	212·13	400·00	282·84	500·00	353·55
46	103·55	71·93	207·10	143·86	310·66	215·80	414·21	287·73	517·76	359·66
47	107·23	73·13	214·47	146·27	321·71	219·40	428·94	292·54	536·18	365·67
48	111·06	74·31	222·12	148·62	338·18	222·94	444·24	297·25	555·30	371·67
49	115·03	75·47	230·07	150·94	345·11	226·41	460·14	301·88	575·18	377·35
50	119·17	76·60	238·35	153·20	357·52	229·81	476·70	306·41	595·87	383·02
51	123·49	77·71	246·97	155·43	370·46	233·14	493·95	310·85	617·44	388·57
52	127·99	78·80	255·99	157·60	383·98	236·40	511·97	315·20	649·97	394·00

TABLE OF DEPTHS AND THICKNESSES—*continued.*

Angle of dip. Degrees.	Horizontal Distances. 100		200		300		400		500	
	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.
53	132·70	79·86	265·41	159·72	398·11	239·59	530·81	319·45	663·52	399·31
54	137·64	80·90	275·27	161·80	412·90	242·70	550·55	323·60	688·19	404·50
55	142·81	81·91	285·63	163·83	428·44	245·74	571·25	327·66	714·17	409·57
56	148·25	82·90	296·51	165·80	444·76	248·71	593·22	330·71	741·28	414·51
57	153·98	83·86	307·97	167·73	461·95	251·60	615·94	335·46	769.93	419·33
58	160·03	84·80	320·06	169·61	480·09	254·41	640·13	339·21	800·16	424·02
59	166·42	85·71	332·85	171·43	499·28	257·14	665·70	342·86	832·13	428·58
60	173·20	86·60	346·41	173·20	519·61	259·80	692·82	346·41	866·02	433·01
61	180·40	87·46	360·81	174·92	541·21	262·38	721·61	349·84	902·02	437·30
62	188·07	88·29	376·14	176·59	564·21	264·88	752·29	353·17	940·36	441·47
63	196·26	89·10	392·52	178·20	588·78	267·30	785·04	356·40	981·30	445·50
64	205·03	89·88	410·06	179·75	615·09	269·63	820·12	359·51	1025·15	449·39
65	214·45	90·63	428·90	181·26	643·35	271·89	857·80	362·52	1072·25	453·15
66	224·60	91·35	449·20	182·71	673·81	274·06	898·41	365·41	1123·01	456·77
67	235·58	92·05	471·17	184·10	706·75	276·15	942·34	368·20	1177·92	460·25
68	247·51	92·72	495·01	185·43	742·52	278·15	990·03	370·87	1237·54	463·59
69	260·51	93·36	521·01	186·71	781·52	280·07	1042·03	373·43	1302·54	466·79
70	274·74	93·97	549·49	187·93	824·24	281·90	1098·98	375·87	1373·73	469·84
71	290·42	94·55	580·84	189·10	871·26	283·65	1161·68	378·20	1452·10	472·75

TABLE OF DEPTHS AND THICKNESSES—*continued.*

Angle of dip. Degrees.	Horizontal Distances. 100 Depth.	100 Thick-ness.	200 Depth.	200 Thick-ness.	300 Depth.	300 Thick-ness.	400 Depth.	400 Thick-ness.	500 Depth.	500 Thick-ness.
72	307·77	95·10	615·53	190·21	923·30	285·31	1231·07	380·42	1538·84	475·52
73	327·08	95·63	654·17	191·26	981·25	286·89	1308·34	382·52	1635·42	478·15
74	348·74	96·12	697·48	192·25	1046·22	288·37	1394·96	384·50	1743·70	480·63
75	373·20	96·59	746·41	193·18	1119·61	289·77	1492·82	386·36	1866·02	482·96
76	401·08	97·03	802·15	194·05	1203·23	291·08	1604·31	388·11	2005·39	485·14
77	433·14	97·43	866·29	194·87	1299·44	292·31	1732·58	389·74	2165·73	487·18
78	470·46	97·81	940·92	195·63	1411·39	293·44	1881·77	391·25	2352·31	489·07
79	514·45	98·16	1028·91	196·32	1543·36	294·48	2057·82	392·65	2572·27	490·81
80	567·13	98·48	1134·25	196·96	1701·38	295·44	2268·51	393·92	2835·64	492·40
81	631·37	98·77	1262·75	197·53	1894·12	296·30	2525·50	395·07	3156·87	493·84
82	711·53	99·02	1423·07	198·05	2134·60	297·07	2846·14	396·10	3557·68	495·13
83	814·43	99·25	1628·87	198·50	2443·30	297·76	3257·73	397·01	4072·17	496·27
84	951·43	99·45	1902·87	198·90	2854·30	298·35	3805·74	397·81	4757·18	497·26
85	1143·00	99·62	2286·01	199·23	3429·01	298·85	4572·02	398·47	5715·02	498·09
86	1430·00	99·75	2860·13	199·51	4290·19	299·26	5720·26	399·02	7150·33	498·78
87	1908·11	99·86	3816·22	199·72	5724·34	299·58	7632·45	399·45	9540·56	499·31
88	2863·62	99·94	5727·25	199·87	8590·87	299·81	11454·50	399·75	14318·12	499·69
89	5728·99	99·98	11457·99	199·97	17186·98	299·87	22915·98	399·93	28644·98	499·92
90	Infinite	100·00	Infinite	200·00	Infinite	300·00	Infinite	400·00	Infinite	500·00

NATURAL SINES, COSINES, AND TANGENTS.

Angle.	Sine.	Diff. per min.	Cosine.	Diff. per min.	Tangent.
0	0000000		1·0000000		0000000
		2909		26	
1	0174524		9998477		0174551
		2908		76	
2	0348995		9993908		0349208
		2906		127	
3	0523360		9986295		0524078
		2904		178	
4	0697565		9975641		0699268
		2900		228	
5	0871557		9961947		0874887
		2895		279	
6	1045285		9945219		1051042
		2890		330	
7	1218693		9925462		1227846
		2884		380	
8	1391731		9902681		1405408
		2877		431	
9	1564345		9876883		1583844
		2869		480	
10	1736482		9848078		1763270
		2860		530	
11	1908090		9816272		1943803
		2851		580	
12	2079117		9781476		2125566
		2840		630	
13	2249511		9743701		2308682
		2828		679	
14	2419219		9702957		2493280
		2816		728	

NATURAL SINES, COSINES, AND TANGENTS—*cont.*

Angle.	Sine.	Diff. per min.	Cosine.	Diff. per min.	Tangent.
15	2588190	2803	9659258	778	2679492
16	2756374	2789	9612617	826	2867454
17	2923717	2774	9563048	876	3057307
18	3090170	2758	9510565	924	3249197
19	3255682	2741	9455186	971	3443276
20	3420201	2724	9396926	1019	3639702
21	3583679	2707	9335804	1067	3838640
22	3746066	2688	9271839	1113	4040262
23	3907311	2667	9205049	1161	4244748
24	4067366	2647	9135455	1207	4452287
25	4226183	2625	9063078	1253	4663077
26	4383711	2603	8987940	1299	4877326
27	4539905	2580	8910065	1343	5095254
28	4694716	2556	8829476	1388	5317094
29	4848096	2531	8746197	1433	5543091

Natural Sines, Cosines, and Tangents—*cont.*

Angle.	Sine.	Diff. per min.	Cosine.	Diff. per min.	Tangent.
30	5000000	2506	8660254	1477	5773503
31	5150381	2480	8571673	1521	6008606
32	5299193	2453	8480481	1563	6248694
33	5446390	2425	8386706	1606	6494076
34	5591929	2397	8290376	1648	6745085
35	5735764	2367	8191520	1689	7002075
36	5877853	2338	8090170	1731	7265425
37	6018150	2308	7986355	1771	7535541
38	6156615	2277	7880108	1812	7812856
39	6293204	2244	7771460	1851	8097840
40	6427876	2212	7660444	1890	8390996
41	6560590	2179	7547096	1928	8692867
42	6691306	2144	7431448	1965	9004040
43	6819984	2109	7313537	2003	9325151
44	6946584	2074	7193398	2039	9656888

NATURAL SINES, COSINES, AND TANGENTS—*cont.*

Angle.	Sine.	Diff. per min.	Cosine.	Diff. per min.	Tangent.
45	7071068	2039	7071068	2074	1·0000000
46	7193398	2003	6946584	2109	1·0355303
47	7313537	1965	6819984	2144	1·0723687
48	7431448	1928	6691306	2179	1·1106125
49	7547096	1890	6560590	2212	1·1503684
50	7660444	1851	6427876	2244	1·1917536
51	7771460	1812	6293204	2277	1·2348972
52	7880108	1771	6156615	2308	1·2799416
53	7986355	1731	6018150	2338	1·3270448
54	8090170	1689	5877853	2367	1·3763819
55	8191520	1648	5735764	2397	1·4281480
56	8290376	1606	5591929	2425	1·4825610
57	8386706	1563	5446390	2453	1·5398650
58	8480481	1521	5299193	2480	1·6003345
59	8571673	1477	5150381	2506	1·6642795

NATURAL SINES, COSINES, AND TANGENTS—*cont.*

Angle.	Sine.	Diff. per min.	Cosine.	Diff. per min.	Tangent.
60	8660254		5000000		1·7320508
		1433		2531	
61	8746197		4848096		1·8040478
		1388		2556	
62	8829476		4694716		1·8807265
		1343		2580	
63	8910065		4539905		1·9626105
		1299		2603	
64	8987940		4383711		2·0503038
		1253		2625	
65	9063078		4226183		2·1445069
		1207		2647	
66	9135455		4067366		2·2460368
		1161		2667	
67	9205049		3907311		2·3558524
		1113		2688	
68	9271839		3746066		2·4750869
		1067		2707	
69	9335804		3583679		2·6050891
		1019		2724	
70	9396926		3420201		2·7474774
		971		2741	
71	9455186		3255682		2·9042109
		924		2758	
72	9510565		3090170		3·0776835
		876		2774	
73	9563048		2923717		3·2708526
		826		2789	
74	9612617		2756374		3·4874144
		778		2803	

NATURAL SINES, COSINES, AND TANGENTS—*cont.*

Angle.	Sine.	Diff. per min.	Cosine.	Diff. per min.	Tangent.
75	9659258		2588190		3·7320508
		728		2816	
76	9702957		2419219		4·0107809
		679		2828	
77	9743701		2249511		4·3314759
		630		2840	
78	9781476		2079117		4·7046301
		580		2851	
79	9816272		1908090		5·1445540
		530		2860	
80	9848078		1736482		5·6712818
		480		2869	
81	9876883		1564345		6·3137515
		431		2877	
82	9902681		1391731		7·1153697
		380		2884	
83	9925462		1218693		8·1443464
		330		2890	
84	9945219		1045285		9·5143645
		279		2895	
85	9961947		0871557		11·430052
		228		2900	
86	9975641		0697565		14·300666
		178		2904	
87	9986295		0523360		19·081137
		127		2906	
88	9993908		0348995		28·636253
		76		2908	
89	9998477		0174524		57·289962
		26		2909	
90	1·0000000		0000000		Infinite.

TO CONVERT NATURAL SCALE ON MAPS TO INCHES TO THE MILE (ENGLISH).

For numbers less than 63,360: divide 63,360 by the natural scale.

For numbers greater than 63,360: divide natural scale by 63,360, *i.e.* multiply by ·0000157$\dot{3}$, to obtain miles to the inch.

Natural Scale.	Inches to Mile.	Miles to Inch.
1 to		
1,000	63·36	..
2,500	25·34	..
5,000	12·67	..
7,500	8·44	..
10,000	6·33	..
25,000	2·53	..
50,000	1·26	..
63,360	**1**	**1**
75,000	..	1·18
100,000	..	1·57
250,000	..	3·92
500,000	..	7·85
750,000	..	11·77
1,000,000	..	15·73
2,000,000	..	31·46
3,000,000	..	47·19
4,000,000	..	62·93
5,000,000	..	78·66
6,000,000	..	94·39
7,000,000	..	110·13
8,000,000	..	125·86
9,000,000	..	141·59
10,000,000	..	157·33

OIL-BEARING AREA OF THE STATES OF THE AMERICAN UNION.

(This Table is taken from a paper by Mr. M. L. Requa in the *Mining Magazine* for 1911, p. 47.)

State.	Square Miles.	State.	Square Miles.
Alaska	100	Brought forward	3180
Alabama	50	New Mexico	80
California	850	New York	300
Colorado	200	Ohio	650
Idaho	10	Oklahoma	400
Illinois	200	Pennsylvania	2000
Indiana	1000	Tennessee	80
Kansas	200	Texas	400
Kentucky	400	Utah	40
Louisiana	60	West Virginia	570
Michigan	80	Wyoming	750
Missouri	30		
		Total	8450
Carried forward,	3180		

QUANTITY OF OIL PER ACRE OF PETROLIFEROUS GROUND FOR GIVEN THICKNESSES OF OIL-SAND, ASSUMING THE SAND TO CONTAIN ONE-TENTH OF ITS BULK OF OIL.

Quantity per Acre.					
Thickness. Feet.	Imperial Gallons.	Barrels of 42 U.S.A. Gallons.	Thickness. Feet.	Imperial Gallons.	Barrels of 42 U.S.A. Gallons.
1	27128·55	775·834	23	623956·65	17844·182
2	54257·10	1551·668	24	651085·20	18620·016
3	81385·65	2327·502	25	678213·75	19395·850
4	108514·20	3103·336	26	705342·30	20171·684
5	135642·75	3879·170	27	732470·85	20947·518
6	162771·30	4655·004	28	759599·40	21723·352
7	189899·85	5430·838	29	786727·95	22499·186
8	217028·40	6206·672	30	813856·50	23275·020
9	244156·95	6982·506	31	840985·05	24050·854
10	271285·50	7758·340	32	868113·60	24826·688
11	298414·05	8534·174	33	895242·15	25602·522
12	325542·60	9310·008	34	922370·70	26378·356
13	352671·15	10085·842	35	949499·25	27154·190
14	379799·70	10861·676	36	976627·80	27930·024
15	406928·25	11637·510	37	1003756·35	28705·858
16	434056·80	12413·344	38	1030884·90	29481·692
17	461185·35	13189·178	39	1058013·45	30257·526
18	488313·90	13965·012	40	1085142·00	31033·360
19	515442·45	14740·846	41	1112270·55	31809·194
20	542571·00	15516·680	42	1139399·10	32585·028
21	569699·55	16292·514	43	1166527·65	33360·862
22	596828·10	17068·348	44	1193656·20	34136·696

QUANTITY OF OIL PER ACRE—*continued.*

Thickness. Feet.	Quantity per Acre. Imperial Gallons.	Barrels of 42 U.S.A. Gallons.	Thickness. Feet.	Imperial Gallons.	Barrels of 42 U.S.A. Gallons.
45	1220784·75	34912·530	73	1980384·15	56635·882
46	1247913·30	35688·364	74	2007512·70	57411·716
47	1275041·85	36464·198	75	2034641·25	58187·550
48	1302170·40	37240·032	76	2061769·80	58963·384
49	1329298·95	38015·866	77	2088898·35	59739·218
50	1356427·50	38791·700	78	2116026·90	60515·052
51	1383556·05	39567·534	79	2143155·45	61290·886
52	1410684·60	40343·368	80	2170284·00	62066·720
53	1437813·15	41119·202	81	2197412·55	62842·554
54	1464941·70	41895·036	82	2224541·10	63618·388
55	1492070·25	42670·870	83	2251669·65	64394·222
56	1519198·80	43446·704	84	2278798·20	65170·056
57	1546327·35	44222·538	85	2305926·75	65945·890
58	1573455·90	44998·372	86	2333055·30	66721·724
59	1600584·45	45774·206	87	2360183·85	67497·558
60	1627713·00	46550·040	88	2387312·40	68273·392
61	1654841·55	47325·874	89	2414440·95	69049·226
62	1681970·10	48101·708	90	2441569·50	69825·060
63	1709098·65	48877·542	91	2468698·05	70600·894
64	1736227·20	49653·376	92	2495826·60	71376·728
65	1763355·75	50429·210	93	2522955·15	72152·562
66	1790484·30	51205·044	94	2550083·70	72928·396
67	1817612·85	51980·878	95	2577212·25	73704·230
68	1844741·40	52756·712	96	2604340·80	74480·064
69	1871869·95	53532·546	97	2631469·35	75255·898
70	1898998·50	54308·380	98	2658597·90	76031·732
71	1926127·05	55084·214	99	2685726·45	76807·566
72	1953255·60	55860·048	100	2712855·00	77583·400

I. C. White, State Geologist of West Virginia, estimates that in a fairly good producing sand a cubic foot of rock contains from 6 to 12 pints of oil. He assumes that in what is considered a good producing district the amount of petroleum which can be obtained from a cubic foot of rock would not be more than a gallon, and that the average thickness of the oil formation would not exceed 5 feet. Taking these figures as a basis, the total yield of oil from an acre of petroliferous territory would be a little over 5000 barrels of 42 U.S.A. gallons.

USE OF THE TERM "OIL-FIELD."

The word "field," as applied to a petroleum-producing area, has been and is very loosely used. Parts of a single continuous area are not infrequently referred to as separate fields; while, on the other hand, a large district, embracing several distinct areas of productive territory, is spoken of as the —— oil-field.

Thus the Balakhani, Sabuntchi, Romani, and Zabrat areas have at various times been spoken of as fields, but are more correctly included at the present time under the title of the Balakhani-Sabuntchi field, the whole forming one continuous piece of productive territory. On the other hand, reference is occasionally made to "the Baku oil-field," in which case the various entirely distinct areas of Balakhani, Bibi-Eibat, Binagadi, etc., are included as one oil-field. Similarly, in the United States "the Appalachian field" includes the New York, Pennsylvania, and West Virginia "fields," which in turn include the various "fields" or "pools" in each of these states.

In the authors' view, the term "oil-field" should be used to indicate a single continuous productive area, and should not be applied to a number of such areas or to parts of them. A typical instance of the separation of one field into two is afforded by the

Boryslaw-Tustanowice area in Galicia, generally, but incorrectly, described as two fields.

MINERALOGICAL NAMES GIVEN TO SOLID BITUMENS AND VARIETIES OF OIL-SHALE.

Albertite.—A variety of asphalt found in veins. Albert county, New Brunswick.

Anthraxolite.—A name given by Prof. Chapman to the tiny globules of bitumen found in the Quebec group, in parts of that province of Canada.

Dopplerite.—A variety of tarry asphalt.

Elaterite.—Elastic bitumen or "mineral indiarubber."

Fichtelite.—A crystalline hydrocarbon of resinous character, found occasionally in peat-bogs.

Gilsonite.—A variety of asphalt found in Utah, also called uintaite.

Grahamite.—A solid bitumen occurring in a vein of considerable size in West Virginia.

Hatchettite.—An ozokerite-like form of bitumen.

Idrialine.—A peculiar bitumen occurring as veins and nodules in the cinnabar-bearing shales of India.

Impsonite.—Similar to albertite. Impson valley, Oklahoma.

Ozokerite.—Crude naturally-occurring paraffin wax.

Parianite.—A name suggested for the asphalt of the Trinidad "Pitch-Lake" on the Gulf of Paria.

Torbanite.—Strictly applicable only to the oil-shale of Torbanehill, in Scotland, but erroneously applied to varieties of kerosene-shale fron New South Wales.

Uintaite.—See Gilsonite.

Wollongongite.—A name given by Prof. Silliman to a specimen of oil-shale from Hartley, N.S.W., really of a different nature from that of the shale found at Wollongong.

Wurtzilite.—A substance resembling gilsonite, found in Wasatch county, Utah.

CONVENTIONAL SIGNS USED ON MAPS OF PETROLEUM LANDS.

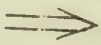

20

Direction of dip of strata, the figures indicating the angle in degrees, while the point of the arrow marks the locality where the observation was made.

This sign is used in the same way as the above by Continental geologists, but in this case the point of junction of the lines marks the position.

Used to denote steeply dipping strata, where the angle of dip is not specified.

Used to denote gently dipping strata, where the angle of dip is not specified.



Pitch of crest of anticlines.

Axes of anticlines are generally indicated by red lines.

This is also used for an anticlinal axis.

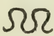
Synclinal axis.


150′ (15°)

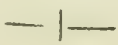
Fault: the short lines marking the downthrow side, and the figures indicating the vertical displacement in feet and the angle of hade from the vertical in degrees.

Horizontal strata.

Undulating strata.



Contorted strata.



Vertical strata.

× ×	Surface indications of oil or gas. Red crosses or dots are also employed.
✳	Used to denote fossil localities.
◌	Site for borehole.
○	Borehole.
□	Hand-dug shaft.
●	Dry hole.
⊙	Productive well (red).
○	Flowing well (red).
○	Gas-well (blue).
⦶	Combination oil- and gas-well (half red and half blue).
○	Water-well (yellow).
⊗	Abandoned oil-well (red).
⊗	Abandoned gas-well (blue).

It will be seen that the signs indicating the status of a well can be modified to bring them up to date without the necessity for any erasure on a plan. Thus, the site for a borehole can easily be altered into a borehole, *i.e.* a well in course of drilling, and the result ultimately attained can be shown by colours. When a flowing well ceases to flow, but is productive by bailing or pumping, it is only necessary to add an inner circle.

It is hoped that the publication of these signs may lead to uniformity in the procedure of marking plans of oil properties.

PART III.

PHYSICAL AND CHEMICAL.

SPECIFIC GRAVITIES OF CRUDE OILS.

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Alaska.	Burls Creek.	..	0·942	Redwood.
	Katalla Bay.	..	0·828	Penniman & Browne.
	Catalla.	Borehole 120 feet.	0·802	Redwood.
	,,	Borehole 355 feet.	0·790	,,
	Oil Creek.	..	0·855	,,
	Argyll (Icy Bay).	..	0·962	,,
	Yakogelty.	..	0·937	,,
Algeria.	Ain Zeft.	1100 feet.	0·888	,,
	Tliouanet.	..	0·820	,,
Argentina.	Comodoro Rivadavia.	1770 feet	0·9306	Rakusin.
	Garrapatal.	..	0·975	Redwood.
	Aybal.	..	0·995	,,
Assam.	Digboi.	Drilled well.	0·858	,,
	Makum.	,,	0·944	,,
Baluchistan.	Khatan.	,,	1·000	,,
Barbados.	..	600 feet.	0·872	,,
Bolivia.	..	3 samples.	0·808, 0·863, & 0·892	,,

Specific Gravities of Crude Oils—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Borneo.	Labuan.	..	0·965	Redwood.
	Sarawak.	..	0·924	,,
	Kutei.	6 samples.	0·848 to 0·865	,,
Burma.	Yenangyaung.	Drilled well.	0·869	,,
	,,	,,	0·875	,,
	,,	Twinza wells.	0·887 & 0·937	,,
	Minbu.	..	0·999	,,
	Pakokku district.	..	0·832	,,
California.	Coalinga.			
	Sec. 14, T. 19 S., R. 15 E.	..	0·9326	Allen.
	Sec. 27, T. 19 S., R. 15 E.	..	0·8718	,,
	Sec. 34, T. 19 S., R. 15 E.	..	0·9299	,,
	Sec. 22, T. 19 S., R. 15 E.	6 samples.	0·9215 to 0·9493	,,
	Sec. 31, T. 19 S., R. 15 E.	6 ,,	0·9341 to 0·9615	,,
	Sec. 6, T. 20 S., R. 15 E.	5 ,,	0·9472 to 0·9738	,,
	Sec. 1, T, 20 S., R. 14 E.	4 ,,	0·9503 to 0·9771	,,
	Sec. 12, T. 20 S., R. 14 E.	..	0·9499	,,
	Sec. 7, T. 20 S., R. 15 E.	2 samples.	0·9501 & 0·9526	,,
	Sec. 13, T. 20 S., R. 14 E.	3 ,,	0·9655, 0·9715, & 0·9750	,,
	Sec. 24, T. 20 S., R. 14 E.	5 ,,	0·9581 to 0·9601	,,
	Sec. 1, T. 20 S., R. 14 E.	..	0·9729	,,
	Sec. 6, T. 21 S., R. 15 E.	..	0·9533	,,

Specific Gravities of Crude Oils—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
California —*cont.*	Coalinga district.	4 samples.	0·779 to 0·979	Redwood.
	Alcalde district.	..	0·9091	Prutzman.
	Fresno Co. (San Benito).	3 samples.	0·8589, 0·905, & 0·915	,,
	Humboldt Co.	4 ,,	0·8263, 0·881, 0·8973 & 0·9014	O'Neill.
	Kern Co. (Kern River).	1052 feet.	0·9609	Cooper.
	,, ,,	850 ,,	0·9792	,,
	,, (Midway).	..	0·9321	Prutzman.
	,, ,,	..	0·9333 to 0·9859	Arnold & Johnson.
	,, (McKittrick).	..	0·9649	Prutzman.
	,, ,,	500 feet.	0·9425	Cooper.
	,, ,,	1377 ,,	0·9396	,,
	,, ,,	900 ,,	0·9747	,,
	,, ,,	..	0·9091 to 0·9859	Arnold & Johnson.
	,, (Sunset).	500 feet.	0·9846	Cooper.
	,, ,,	790 ,,	0·9816	,,
	,, ,,	..	0·9333 to 0·9929	Arnold & Johnson.
	,, (Temblor).	..	0·9333 to 0·9722	Arnold & Johnson.

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
California —*cont.*	Los Angeles Co. (East End field, Los Angeles City).	1225 feet.	0·9699	Cooper.
	Los Angeles Co. (East End field, Los Angeles City).	1275 ,,	0·9774	,,
	Los Angeles Co. (Middle field, Los Angeles City).	1340 ,,	0·9559	,,
	Los Angeles Co. (Middle field, Los Angeles City).	1060 ,,	0·9706	,,
	Los Angeles Co. (Middle field, Los Angeles City)..	1080 ,,	0·9736	,,
	Los Angeles Co. (West End field, Los Angeles City),	1264 ,,	0·9487	,,
	Los Angeles Co. (West End field, Los Angeles City).	410 ,,	1·010	,,
	Los Angeles Co. (West End field, Los Angeles City).	370 ,,	0·9860	,,
	Los Angeles Co. (Newhall district).	662 ,,	0·9474	Prutzman.
	Los Angeles Co. (Newhall district).	1000 ,,	0·9687	Cooper.
	Los Angeles Co. (Newhall district).	750 ,,	0·9758	,,

Specific Gravities of Crude Oils—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
California —*cont.*	Los Angeles Co. (Newhall district).	1400 feet.	0·8367	Cooper.
	Los Angeles Co. (Pico Cañon district).	29 samples.	0·827 to 0·927	Redwood.
	Los Angeles Co. (Pico Cañon).	..	0·8367	Cooper.
	,, (Puente).	1425 feet.	0·8775	,,
	,, ,,	..	0·880	Redwood.
	,, (Whittier).	..	0·9291	Cooper.
	,, ,,	2300 feet.	0·9669	,,
	Orange Co. (Fullerton).	680 ,,	0·9378	,,
	,, ,,	2404 ,,	0·9399	,,
	,, ,,	1705 ,,	0·8536	,,
	,, ,,	1515 ,,	0·9147	,,
	Santa Barbara Co. (Lompoc).	2500 ,,	0·9574	,,
	,, (Summerland)	..	0·9665	,,
	,, ,,	..	0·9722 to 1·0000	Redwood.
	,, ,,	260 feet.	0·9603	Cooper.
	,, ,,	Submarine well.	0·9521	Mabery & Zonl.
	,, (Santa Maria).	1600 feet.	0·8882	Cooper.
	,, ,,	6 samples.	0·891 to 0·926	O'Neill.
	Ventura Co. (Adams Cañon).	2745 feet.	0·8814	Cooper.

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
California —*cont.*	Ventura Co. (Buckhorn).	950 feet.	0·9685	Cooper.
	„ (Piru district).	1100 „	0·8838	„
	„ (Santa Paula district).	1000 „	0·8900	„
Canada.	Petrolea.	..	0·858	Redwood.
	Gaspé.	2057 feet.	0·853	„
	„	906 „	0·877	„
	„	2361 „	0·847	„
	„	1946 „	0·861	„
	New Brunswick.	5 samples.	0·838 to 0·862	„
Colombia.	..	2 „	0·926 & 0·963	„
Colorado.	Boulder.	2 „	0·806 & 0·814	„
	„	..	0·8304	Hoffman & Salathe
	Florence.	48 samples.	0·8664 to 0·8762 (mean 0·8709)	Washburne.
	Mesa Co.	150 feet.	0·8345	Day.
Ecuador	..	2 samples.	0·928 & 0·953	Redwood
Egypt.	Jemsa.	..	0·823	„
	Jebel Tanka.	Shallow well.	0·958	„
England.	Derbyshire.	..	0·857	„
	Somersetshire.	..	0·816	„

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
England —*cont.*	Nottinghamshire (Kelham).	Shallow well.	0·914	Redwood.
Galicia.	Boryslaw.	..	0·842	Gintl.
	,,	..	0·864	Wielezynski.
	Kleczany.	..	0·802	Redwood.
	Kobylany.	..	0·853	,,
	Kosmacz.	..	0·876	Wielezynski.
	Mraznica.	..	0·880	,,
	Potok.	..	0·798	Redwood.
	,,	..	0·831	Wielezynski.
	Sloboda-Rungurska.	Samples from 15 drilled wells.	0·830 to 0·868	Redwood.
	Urycz.	..	0·878	Wielezynski.
	Ustrzyki district.	Samples from 5 drilled wells.	0·835 to 0·844	Redwood.
	Wietrzno district.	..	0·846 to 0·859	,,
Germany.	Oelheim.	..	0·913	,,
	,,	..	0·909	Kessler.
	Elsass.	..	0·873	Redwood.
	Pechelbronn.	..	0·890	Kessler.

Specific Gravities of Crude Oils—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Germany —*cont.*	Wietze-Steinförde.	3 samples.	0·941, 0·943, & 0·951	Redwood.
	Wietze.	..	0·881 & 0·900	Kessler.
Greece.	Zante.	2 samples.	1·005 & 1·020	Redwood.
Hungary.	Kriva-Olyka.	..	0·907	,,
	Maramaros.	..	0·823	Rakusin & Laszlo.
	Szacsal.	..	0·842	Redwood.
	,,	1735 feet.	0·8306	Wielezynski.
Illinois.	Clark Co. (Johnson Township)	606 ,,	0·863	Day.
	,, ,, ,,	610 ,,	0·866	,,
	,, ,, ,,	480 ,,	0·868	,,
	,, ,, ,,	..	0·887	Grout.
	,, (Parker Township).	..	0·873	,,
	,, (Oblong Township).	..	0·870	,,
	Crawford Co. (Robinson Pool))	970 feet.	0·854	Day.
	,, ,, ,,	945 ,,	0·871	,,
	,, ,, ,,	960 ,,	0·838	,,
	,, (Montgomery Township).	970 ,,	0·915	,,
	,, (Montgomery Township).	965 ,,	0·919	,,

Specific Gravities of Crude Oils—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Illinois—*cont.*	Cumberland Co. (Union Township).	577 feet.	0·878	Day.
	Lawrence Co. (Bridgeport Pool)	1435 ,,	0·833	,,
	,, ,, ,,	900 ,,	0·854	,,
	,, ,, ,,	900 ,,	0·864	,,
	,, ,, ,,	1500 ,,	0·828	,,
Indiana.	..	6 samples.	0·848 to 0·949	Redwood.
	Vigo Co. (Terre Haute).	..	0·879	Noyes.
	Grant Co. (Van Buren).	..	0·853	,,
Italy.	Montechino.	..	0·787	Redwood.
	Miano.	2 samples.	0·832 & 0·867	,,
	Neviano.	Drilled well.	0·805	,,
	Ozzano.	,,	0·807	,,
Ivory Coast.	..	..	0·959	,,
Japan.	Amaze.	2100 feet.	0·7877	Rakusin.
	Formosa (Shiukkoko).	..	0·8284	Fukutome.
	Urase lease.	..	0·840	Redwood.
	Kubiki lease.	..	0·823	,,
	Kamata lease.	..	0·927	,,
	Miyagawa lease.	..	0·807	,,
	Niitsu lease.	..	0·932	,,

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Japan—*cont.*	Amaze lease.	..	0·841	Redwood
	Enshyu lease.	..	0·792	,,
	Akita lease.	..	0·917	,,
Java.	..	3 samples.	0·881, 0·881, & 0·844	,,
Kansas.	Allen Co. (Humboldt).	851 feet.	0·8895	Day.
	,, ,,	850 ,,	0·8822	,,
	,, (Chanute).	751 ,,	0·8647	,,
	,, ,,	Sample taken from pipe-line.	0·8637	,,
	,, (Moran).	735 feet.	0·8794	,,
	Chautauqua Co. (Peru).	1100 ,,	0·8454	,,
	,, ,,	Sample taken from pipe-line.	0·8526	,,
	Elk Co. (Longton).	585 feet.	0·8637	,,
	Franklin Co. (Rantoul).	350 ,,	0·8750	,,
	Miami Co. (Paola).	360 ,,	0·8511	,,
	Montgomery Co. (Bolton).	1180 ,,	0·8424	,,
	,, (Coffeyville).	625 ,,	0·8717	,,
	Neosho Co. (Erie).	520 ,,	0·8658	,,
	Wilson Co. (Neodesha).	800 ,,	0·8373	,,
	,, ,,	820 ,,	0·8368	,,
	,, ,,	..	0·835	Bailey.

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Kentucky.	Allen Co. (Petroleum).	810 feet.	0·8490	Day.
	Bath Co. (Ragland).	366 ,,	0 8963	,,
	Lawrence Co.	320 ,,	0·853	Peter.
	Morgan Co. (First Cow Run Sand).	..	0·8092	Day.
	Wayne Co. (Parnell).	892 feet.	0·8083	,,
	,, (Sinking).	600 ,,	0·8154	,,
	,, (Oil Valley).	690 ,,	0·8154	,,
	,, (Johnson Fork).	..	0·8408	,,
	,, (Cooper).	..	0·8718	,,
	,, (Turkey Rock).	..	0 8163	,,
	,, (Rocky Branch).	187 feet.	0·9021	,,
	,, (Parmleysville).	..	0·8348	,,
Louisiana.	..	..	0·829	Redwood.
	Anse-Le-Butte.	600 feet.	0·9392	Coates & Best.
	Bayou Bouillon.	..	0·859	Metz & Custis.
	,, ,,	900 feet.	0·9669	Coates & Best.
	Caddo.	2225 ,,	0·8081	Day.
	,,	2300 ,,	0·9109	,,
	Welsh.	..	0·938	Thiele.

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Mexico.	Potrero del Llano.	..	0·8696	Day.
	Isthmus of Tehuantepec.	2 samples.	0·933 & 0·959	Redwood.
	Ebano.	..	1·012	,,
Morocco.	..	3 samples.	0·849, 0·870, & 0·871	,,
Newfoundland.	..	3 ,,	0·798, 0·805, & 0·843	,,
New Zealand.	Taranaki.	Surface oil.	0·971	,,
	,,	Drilled well.	0·840	,,
	Gisborne.	Waitangi well.	0·885	,,
	,,	..	0·8642	Day.
Ohio.	Fairfield Co. (Bremen).	2462 feet.	0·7848	,,
	,, (Pleasantville)	2345 ,,	0·8046	,,
	Knox Co. (Bladensburg).	2771 ,,	0·8469	,,
	Lima.	..	0·839	Redwood.
	Monroe Co. (Decker).	1500 feet.	0·7955	Day.
	,, (Jerusalem).	1200 ,,	0·7848	,,
	,, (Clarington).	1504 ,,	0·7968	,,
	,, (Graysville).	..	0·7782	,,
	,, (Olive).	..	0·8260	,,
	,, (Griffith).	..	0·7937	,,
	,, (Bethel).	..	0·7739	,,

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Ohio—*cont.*	Morgan Co. (Milner).	325 feet.	0·8046	Day.
	Nobel Co. (Macksburg).	516 „	0·8154	„
	„ „	..	0·829	Redwood.
	„ (Belle Valley).	1465 feet.	0·8240	Day.
	Perry Co. (San Toy).	1260 „	0·8240	„
	„ (Crooksville).	3407 „	0·8014	„
	„ (New Straitsville).	3106 „	0·7923	„
	Vinton Co. (Jackson).	2480 „	0·7959	„
	Washington (Liberty).	827 „	0·8023	„
	„ „	1260 „	0·7865	„
Oklahoma.	Creek Co. (Bird Creek and Skiatook).	Sample taken from pipe-line.	0·8626	„
	Creek Co. (Bird Creek and Skiatook).	1200 feet.	0·8563	„
	Creek Co. (Skiatook).	1408 „	0·8480	„
	„ „	1466 „	0·8328	„
	„ (Glenn).	1500 „	0·8459	„
	„ „	Sample taken from pipe-line.	0·8464	„
	„ „	1523 feet.	0·8373	„
	„ (Mounds).	2340 „	0·8631	„
	Kiowa Co. (Gotebo).	365 „	0·8480	„

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Oklahoma —*cont.*	Muskogee Co. (Muskogee, new field).	1553 feet.	0·8328	Day.
	Muskogee Co. (Muskogee, new field).	1574 ,,	0·8343	,,
	Muskogee Co. (Muskogee, new field).	1702 ,,	0·8333	,,
	Muskogee Co. (Muskogee, new field).	Sample taken from pipe-line tank.	0·8358	,,
	Muskogee Co. (Muskogee, old field).	1000 feet.	0·8328	,,
	Nowata Co. (Childers).	735 ,,	0·8449	,,
	,, (Delaware).	830 ,,	0·8424	,,
	Nowata & Rogers Cos. (Shallow Sand).	Sample taken from pipe-line.	0·8537	,,
	Okmulgee Co. (Morris).	1600 feet.	0·8383	,,
	,, (Bald Hill).	1680 ,,	0·8403	,,
	Osage Co. (Bartlesville).	Sample taken from pipe-line.	0·8584	,,
	,, ,,	1487 feet.	0·8521	,,
	,, ,,	3 samples.	0·859, 0·877, & 0·886	Redwood.
	,, ,,	1420 feet.	0·856	,,

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Oklahoma —*cont.*	Osage Co. (Bartlesville).	1750 feet.	0·872	Redwood.
	,, (Shallow Sand).	1088 ,,	0·8398	Day.
	Pawnee Co. (Cleveland, city limits).	..	0·8516	,,
	Pawnee Co. (Cleveland, Jordan Valley Township).	1174 feet.	0·8403	,,
	Pawnee Co. (Cleveland, Jordan Valley Township).	1750 ,,	0·8605	,,
	Pawnee Co. (Cleveland, Jordan Valley Township).	1600 ,,	0·8669	,,
	Rogers Co. (Alluwe).	400 ,,	0·8413	,,
	,, (Chelsea).	500 ,,	0·8511	,,
	,, ,,	..	0·855	Redwood.
	Seminole Co. (Wewoka).	1625 feet.	0·8844	Day.
	Tulsa Co. (Red Fork).	638 ,,	0·8368	,,
	,, ,,	601 ,,	0·8323	,,
	,, ,,	1200 ,,	0·8358	,,
	,, ,,	Sample taken from pipe-line.	0·8594	,,
	Washington Co. (Dewey, and north of Dewey).	1200 feet.	0·8605	,,
	Washington Co. (Dewey, and north of Dewey).	525 ,,	0·8772	,,

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Oklahoma —*cont.*	Washington Co. (Webber).	1250 feet.	0·8368	Day.
	,, ,,	1300 ,,	0·8547	,,
Pennsylvania.	Bradford.	2 samples.	0·810 & 0·819	Redwood.
	Parker (Clarion).	..	0·797	,,
	Thorn Creek.	..	0·802	,,
	Stoneham.	..	0·802	,,
	Washington.	30 samples.	0·771 to 0·828	,,
	Perry Co.	..	0·790	Bourgougnon.
	Venango Co.	..	0·882	Silliman.
Persia.	Tchia-Sourkh.	Drilled well.	0·815	Redwood.
	..	6 samples.	0·777, 0·839, 0·846, 0·863, 0·900, & 1·016	,,
Peru.	Negritos.	..	0·843	,,
	Zorritos.	..	0·810 to 0·840	Weinstein.
Philippine Islands.	Cebu.	3 samples.	0·809, 0·819, & 0·838	Redwood.
	Leyte.	..	0·926	,,
	Tayabas.	120 feet.	0·8318	Day.
Rumania.	Berca.	..	0·801	Edeleanu.
	Bustenari.	Average from 25 drilled wells.	0·8541	Redwood.

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Rumania —*cont.*	Bustenari.	..	0·820 to 0·926	Aisinmann.
	,,	..	0·861	Edeleanu.
	Campeni Bacau.	..	0·815	,,
	Campina.	Average from 12 drilled wells.	0·8360	Redwood.
	Comanesti.	..	0·843	Edeleanu.
	Matita.	..	0·807	,,
	Moinesti.	..	0·858	,,
	Policiori.	..	0·816	,,
	Sarata-Monteoru.	..	0·892	,,
Russia.	Balakhani.	2 samples.	0·873 & 0·879	Redwood.
	Bibi-Eibat.	1820 feet.	0·8604	Rakusin.
	,,	2212 ,,	0·8866	,,
	Ferghana.	..	0·8935	Bobrzynski.
	,,	..	0·872	Andreiev.
	Grozni.	4 samples.	0·874, 0·884, 0·894 & 0·927	Redwood.
		..	0·852	Kharitchkov.
	,, West.	..	0·906 to 0·910	,,
	Ilsky.	2 samples.	0·853 & 0·942	Redwood.
	Kudako.	2 ,,	0·860 & 0·936	,,
	Maikop.	..	0·827	,,

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Russia—*cont.*	Maikop.	426 feet.	0·860	v. Glasenapp.
	,,	..	0·8552	Kharitchkov.
	Surakhani.	..	0·780	Redwood.
	Suvorovsk.	..	0·914	,,
	Gurieff district.	7 samples.	0·839, 0·869, 0·876, 0·880, 0·903, 0·904, & 0·908	,,
	Tcheleken.	8 ,,	0·839, 0·841, 0·841, 0·843, 0·850, 0·859, 0·873, & 0·878	,,
	Island of Sakhalin.		0·922	,,
Spain.	Conil (near Cadiz).	..	0·837	,,
	Huidobro.	..	0·921	,,
	Villamartin.	..	0·7973	Day.
Sumatra.	Langkat.	3 samples.	0·771, 0·789, & 0·857	Redwood.
	Iliran Palembang.	4 ,,	0·925, 0·934, 0·964, & 0·980	,,
	Muara Enim.	3 ,,	0·813, 0·833, & 0·923	,,

Specific Gravities of Crude Oils—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
Texas.	Bexar Co. (San Antonio).	..	0·88	Palm.
	,, ,,	..	0·9179	Worell.
	Corsicana.	1000 feet.	0·8500	Day.
	Hardin Co. (Sour Lake).	..	0·963	Thiele.
	,, ,,	..	0·9222	Fenneman.
	,, (Batson).	1150 feet.	0·8761	,,
	,, ,,	..	0·8888	,,
	Jefferson Co. (Beaumont).	1200 feet.	0·9228	Coates & Best.
	,, ,,	..	0·9206	Thiele.
	,, ,,	..	0·920	Mabery.
	,, (Spindletop).	Average.	0·9227	McNamara.
	,, ,,	..	0·876	Redwood.
	Ross.	265 feet.	0·9079	Day.
	Saratoga.	1100 ,,	0·9466 to 0·9594	Fenneman.
Timor.	..	2 samples.	0·817 & 0·825	Redwood.
Trinidad.	Aripero.	..	0·938	,,
	La Brea.	..	0·971	,,
Tunis.	..	..	0·965	,,
Utah.	San Juan Co.	263 feet.	0·8264	Day.
	Unita Co.	..	0·9511	,,
Venezuela.	..	4 samples.	0·855, 0·868, 0·878, & 0·887	Redwood.

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
West Virginia.	Doddridge Co. (Eagle Mills).	..	0·7941	Day.
	,, (Morgansville).	..	0·8014	,,
	,, (Sullivan).	..	0·7874	,,
	Harrison Co. (Shinnston).	2015 feet.	0·7977	,,
	Lewis Co. (Gantz Sand).	..	0·8235	,,
	Pleasants Co.(Horseneck Sand).	280 feet.	0·8149	,,
	,, (Maxton Sand).	..	0·8173	,,
	,, (1st.Cow Run Sand)	994 feet.	0·8135	,,
	,, (1st.Cow Run Sand)	1040 ,,	0·7896	,,
	,, (Big Injun Sand).	1443 ,,	0·7861	,,
	Ritchie Co. (Moats).	1717 ,,	0·8895	,,
	,, ,,	1538 ,,	0·8102	,,
	,, (Elm Run).	2145 ,,	0·8000	,,
	,, (Volcano).	600 ,,	0·8130	,,
	,, (Long Run).	1588 ,,	0·8037	,,
	,, (McFarlan).	1494 ,,	0·8005	,,
	,, (Cairo).	1654 ,,	0·8154	,,
	,, (Highland).	..	0·7865	,,
	,, (Whiskey Run).	1786 feet.	0·7684	,,
	,, (Wolf Pen).	1750 ,,	0·7874	,,
	,, (Harrisville).	1850 ,,	0·7977	,,
	,, (Clay).	1790 ,,	0·7959	,,
	,, (Flanigan).	..	0·7986	,,

SPECIFIC GRAVITIES OF CRUDE OILS—*continued.*

Country.	Locality.	Remarks.	Sp. Gr.	Authority.
West Virginia —*cont.*	Ritchie Co. (Inland).	..	0·7986	Day
	,, (Prunty).	..	0·7701	,,
	Tyler Co. (Alvy-Gordon Sand).	2670 feet	0·8078	,,
	Wood Co. (Pohick).	..	0·8140	,,
	,, (Braz).	634 feet.	0·7950	,,
	,, (Williams).	850 ,,	0·8055	,,
	,, (Eppelsin).	920 ,,	0·8111	,,
	,, (Union).	1215 ,,	0·8250	,,
	,, (Volcano).	350 ,,	0·8750	,,
Wyoming.	Arapahoe.	..	0·861	Redwood.
	Big Horn Co. (Bonanza).	..	0·8446	Slosson.
	Bonanza.	..	0·862	Redwood.
	Crook Co. (Belle Fourche).	..	0·915	Slosson.
	Douglas.	..	0·959	Redwood.
	Lander.	2 samples.	0·910 & 0·935	,,
	Natrona Co. (Salt Creek).	..	0·9095	Slosson.
	Salt Creek.	2 samples from drilled wells.	0·905 & 0·909	Redwood.
	Uinta Co. (Spring Valley).	..	0·8329	Salathe.
	,, ,,	..	0·8211	Gray.
	,, ,,	650 feet.	0·825	Falkenau.
	,, ,,	..	0·810	Mabery.

YIELD OF PRODUCTS OF VARIOUS CRUDE OILS.

ALASKA.

	Per cent.	Per cent.
Benzine	24·8	..
Kerosene	53·9	19·0
Intermediate and lubricating oils with solid hydrocarbons	16·7	78·6
Coke	1·2	1·7

Redwood.

KATALLA BAY.

° C.	
0–150	21·0
150–300	51·0
Residuum	28·0

Penniman & Browne.

ALGERIA.

AIN ZEFT.

Benzine	6·2
Kerosene	20·4
Intermediate and lubricating oils with solid hydrocarbons	61·9
Coke	8·0

Redwood.

ARGENTINA.

COMODORO RIVADAVIA.

Benzine	2·5
Kerosene	4·7
Gas oil	9·95
Heavy lubricating oil	27·45
Asphalt	55·4

Rakusin.

ASSAM.

Digboi.

	Per cent.
Benzine	8·8
Kerosene	37·8
Intermediate and lubricating oils with solid hydrocarbons	49·4
Coke	3·8

Redwood.

BORNEO.

Kutei.

	Per cent.	Per cent.
Benzine	17·4	4·6
Kerosene	46·0	43·3
Intermediate and lubricating oils with solid hydrocarbons	33·3	50·7
Coke	1·3	1·6

Redwood.

Labuan.

Intermediate and lubricating oils with solid hydrocarbons	97·1
Coke	2·6

Redwood.

Sarawak.

Intermediate and lubricating oils with solid hydrocarbons	94·3
Coke	3·3

Redwood.

BURMA.

Lower Burma.

	Per cent.
Benzine	9·0
Kerosene	57·5
Intermediate and lubricating oils with solid hydrocarbons	32·0
Coke	0·2
	Redwood.

Benzine	9·25
Kerosene	69·25
Intermediate and lubricating oils with solid hydrocarbons	21·25
Coke	0·1
	Redwood.

Yenangyaung.

Benzine	1·35
Kerosene	25·78
Intermediate and lubricating oils with solid hydrocarbons	67·98
	Redwood.

CALIFORNIA.

Coalinga.

	Per cent. East side.	Per cent. West side.
Naphtha	29·84	nil.
Burning oil	57·72	10·71
Lubricating oil	3·68	29·55
Asphaltum	2·68	57·42
Paraffin wax	3·54	nil.
Residue	1·20	0·59
Loss	1·34	1·43
	I. C.	*Allen.*

CALIFORNIA—*continued*.

Kern River.

° C.	Per cent.
150–300	20·2
Residuum	79·8
	Cooper.

Los Angeles.

150–270	20·0
Residuum	80·0
	Prutzman.

McKittrick.

150–270	11·0
Residuum	89·0
	Prutzman.

Midway.

150–270	5·7
Residuum	94·3
	Prutzman.

Pico Cañon.

Benzine	15·0
Kerosene	45·0
Intermediate and lubricating oils with solid hydrocarbons	32·0
	Redwood.

Puente.

Benzine	12·5
Kerosene	22·0
Intermediate and lubricating oils with solid hydrocarbons	42·6
Coke	10·2
	Redwood.

CALIFORNIA—*continued.*

SUMMERLAND.

° C.	Per cent.
150–250	6·5
Residuum	93·5

O'Neill.

SUNSET.

0–150	4·1
150–270	12·3
Residuum	83·6

Prutzman.

VENTURA CO.

0–150	10·4
150–300	28·0
Residuum	61·6

Calif. State Min. Bureau.

WHITTIER.

0–150	5·0
150–270	20·0
Residuum	75·0

Prutzman.

CANADA.

GASPÉ.

Benzine	15·9
Kerosene	41·3
Intermediate and lubricating oils with solid hydrocarbons	40·5
Coke	1·4

Redwood.

CANADA—*continued*.

NEW BRUNSWICK.

	Per cent.
Benzine	2·0
Kerosene	23·5
Intermediate and lubricating oils with solid hydrocarbons	67·0
Coke	5·3

Redwood.

PETROLEA.

Benzine	2·5
Kerosene	57·5
Intermediate and lubricating oils with solid hydrocarbons	
Coke	4·08

Redwood.

COLORADO.

BOULDER.

Benzine	18·0
Kerosene	39·7
Intermediate and lubricating oils with solid hydrocarbons	36·8
Coke	0·6

Redwood.

° C.	
0–150	16·0
150–300	40·0
Residuum	44·0

Hoffmann & Salathe.

Gasolene	20–22
Water-white oil	38–40
Gas oil	12·5–15

COLORADO—*continued.*

Boulder—*continued.*

	Per cent.
Wax oil	15
Residuum	6–7
Loss	1–2

Washburne.

Florence.

Naphtha	4·15
Water-white	30·45
"Mineral seal" oil	2·5
Gas distillate	22·9
Wax distillate	40·0

Washburne.

Gasolene	1·5
Burning oil	27·0
Residuum	70·2
Paraffin	9·23

Washburne.

ECUADOR.

Benzine	2·14
Kerosene	15·61
Intermediate and lubricating oils with solid hydrocarbons	70·89
Coke	8·82

Redwood.

EGYPT.

Jebel Zeit.

Benzine	16·8
Kerosene and lubricants	78·9
Residuum	4·6

Khediv. Lab.

EGYPT—*continued.*

Jebel Zeit—*continued*

° C.	Per cent.
0–300	25·0
300–350	61·0
Residuum and loss	14·0
	Jacunski.

Jemsa.

0–300	23·5
300–350	54·5
Residuum and loss	22·0
	Jacunski.

GALICIA.

Boryslaw.

0–150	9·7
150–300	29·4
Residuum	60·4
	Freund.
0–150	10·2
150–300	29·2
Residuum	59·2
	Freund

Harklowa.

Benzine	4·0
Kerosene	23·0
Intermediate and lubricating oils with solid hydrocarbons	58·6
Coke	8·75
	Redwood.

Kleczany.

Light oil	3·40
Petroleum distillate, 150°–300° C.	38·60
Lubricating oil	54·50
Coke and loss	3·50
	Nawratil.

GALICIA—*continued.*

Lanczyn

	Per cent.
Benzine	8·4
Kerosene	36·5
Intermediate and lubricating oils with solid hydrocarbons	50·3

Redwood.

Lodyna.

Petroleum spirit	17·0
Kerosene	30·0
Intermediate and heavy oils	45·5
Coke	4·0

Redwood.

Sloboda-Rungurska.

	Per cent.	Per cent.
Petroleum spirit	12·5	8·8
Kerosene	37·5	37·4
Intermediate and heavy oils	40·7	40·0
Coke	8·3	7·0

Redwood.

Tustanowice.

° C.	
0–150	15·9
150–300	32·6
Residuum and loss	51·5

Zaloziecki.

Ustrzyki District.

Petroleum spirit	9·6
Kerosene	38·4
Intermediate and heavy oils	44·3
Coke	3·1

Redwood.

GERMANY.

Elsass.

	Per cent.	Per cent.
Benzine	10·0	4·0
Kerosene	26·1	31·4
Intermediate and lubricating oils with solid hydrocarbons	57·1	52·7
Coke	5·7	7·9

Redwood.

Elsass (Pechelbronn).

Benzine	3·0
Burning oil	23·0
Intermediate oil	26·0
Lubricating oil	46·0
Paraffin content	low

Kessler.

Hanover (Oelheim).

Benzine	0·0
Burning oil	17·0
Intermediate oil	29·0
Lubricating oil	53·0
Paraffin content	low

Kessler.

Hanover (Wietze).

Benzine	0·0	3·0
Burning oil	24·0	29·0
Intermediate oil	31·0	27·0
Lubricating oil	41·0	40·0
Paraffin content	low	low

Kessler.

GERMANY—*continued.*

Hanover (Horst).

	Per cent.
Benzine	1·94
Kerosene	35·1
Intermediate and lubricating oils with solid hydrocarbons	59·0
Coke	2·0

Redwood.

GOLD COAST COLONY.

Bonyere.

Light petroleum	7·1
Kerosene	49·0
Lubricating oil	23·5
Residue and loss	20·4

Bull. Imp. Inst.

HUNGARY.

Körösmezö.

° C.	
0–150	12·97
150–300	48·29
Residuum	38·74

v. Kaleczinsky.

Sosmezö.

0–150	2·27
150–300	35·87
Residuum	61·56

v. Kaleczinsky.

Szaczal.

0–150	16·71
150–300	28·21
Residuum	53·17

v. Kaleczinsky.

HUNGARY—*continued.*

Zsibo.

° C.	Per cent.
0–150	3·0
150–300	34·0
Residuum	63·0
	Höfer.

ILLINOIS.

Clark County (Weaver Lease).

0–150	4·4
150–200	11·0
200–250	9·1
250–300	13·1
300–350	50·0
Coke and loss	12·4
	Grout.

Clark Co. (Parker Township).

0–150	10·5
150–300	34·0
	Day.

Clark Co. (Johnson Township).

0–150	11·5
150–300	35·0
	Day.

Crawford Co. (Robinson Pool).

0–150	16·0
150–300	34·0
	Day.

Cumberland Co. (Union Township).

0–150	10·1
150–300	34·0
	Day.

ILLINOIS—*continued.*

Lawrence Co. (Bridgeport).

° C.	Per cent.
0–150	12·0
150–300	35·0
Residuum	49·2
Paraffin content	4·31

Day.

Litchfield.

0-150	1·3
150–200	·5
200–250	1·2
250–300	15·2
300	71·1
Coke and loss	10·7

Grout.

INDIANA.

Grant Co. (Van Buren).

0–150	7·2
150–300	32·6
Residuum	60·2

Noyes.

Vigo Co. (Terre Haute).

150–300	39·6
Residuum	60·4

Noyes.

ITALY.

Neviano.

Benzine	18·9
Kerosene	69·5
Intermediate and lubricating oils with solid hydrocarbons	11·0
Coke	0·2

Redwood.

ITALY—*continued.*

Ozzano.

	Per cent.	Per cent.
Benzine	37·3	43·9
Kerosene	40·4	46·5
Intermediate and lubricating oils with solid hydrocarbons	19·9	5·5
Coke	0·3	..

Redwood.

JAPAN.

Echigo Prov. (Myohoji).

°C.	
0–150	33·5
150–300	49·0
Residuum	17·5

Kondo.

Echigo (Gendoji).

0–150	29·0
150–300	50·0
Residuum	21·0

Kondo.

Shinano (Minauchi).

150–300	20·0
Residuum	80·0

Kondo.

Totomi Prov. (Sugegaya).

0–150	47·0
150–300	44·6
Residuum	13.4

Kondo.

Ugo (Akita).

150–300	37·5
Residuum	62·5

Kondo.

JAVA.

	Per cent.	Per cent.
Benzine	0·0	1·5
Kerosene	46·8	56·6
Intermediate and lubricating oils with solid hydrocarbons	46·1	41·1
Coke	7·1	1·4

Redwood.

KANSAS.

HUMBOLDT.

°C.	
0–150	1·0
150–300	29·0
Residuum	68·9
Paraffin content	2·93

Day.

NEODESHA.

0–150	1·0
150–300	40·5
Residuum	57·0
Paraffin content	5·79

Day.

PERU.

0–150	7·0
150–300	32·5
Residuum	58·7
Paraffin content	3·81

Day.

KENTUCKY.

ALLEN CO.

0–150	12·5
150–300	41·0
Residuum	45·3
Paraffin content	3·65

Day.

KENTUCKY—*continued.*

Wayne Co. (Parmleysville).

° C.	Per cent.
0–150	13·0
150–300	36·0
Residuum	47·9
Paraffin content	5·09

Day.

Wayne Co. (Parnell).

0–150	27·0
150–300	33·0
Residuum	37·3
Paraffin content	2·47

Day.

LOUISIANA.

Anse-Le-Butte.

150–300	16·0
Residuum	84·0

Coates & Best.

Caddo.

150–300	10·5
Residuum	88·2

Day.

Jennings.

150–300	41·0
Residuum	59·0

Coates & Best.

Welsh.

150–300	19·0
Residuum	81·0

Coates & Best.

MEXICO.

	Per cent.	Per cent.
Kerosene	37·0	27·75
Intermediate and lubricating oils with solid hydrocarbons	62·25	66·0
Coke	0·5	..

Redwood.

Benzine	..	2·6
Kerosene	..	15·6
Intermediate and lubricating oils with solid hydrocarbons	88·5	66·3
Coke	6·5	12·1

Redwood.

Isthmus of Tehuantepec.

Intermediate and lubricating oils with solid hydrocarbons	91·3	90·0
Coke	6·7	4·0

Redwood.

MICHIGAN.

Port Huron.

° C.	
0–150	15·0
150–300	55·0
Residuum	30·0

Min. Res., U.S., 1905.

MISSOURI.

Belton, Cass Co.

0–150	10·0
150–300	19·0
Residuum	71·0
Paraffin content	8·0

Frankforter.

NEWFOUNDLAND.

	Per cent.	Per cent.
Benzine	18·0	12·7
Kerosene	38·1	55·2
Intermediate and lubricating oils with solid hydrocarbons	41·0	28·7
Coke	1·2	1·0

Redwood.

NEW ZEALAND.

Gisborne.

	Per cent.
Gasoline (0-150° C.)	0·0
Kerosene (150–300° C.)	43·0
Residuum	57·1
Paraffin content	8·88

Day.

Taranaki.

Gasoline (0–150° C.)	10·0
Kerosene (150–300° C.)	50·0
Residuum	39·9
Paraffin content	14·78

Day.

Taranaki (Drilled well).

Kerosene	48·25
Intermediate and lubricating oils with solid hydrocarbons	51·25
Coke	0·4

Redwood.

OHIO.

Bremen.

° C.	Per cent.
0–150	15·0
150–300	40·0
Residuum	42·0
Paraffin content	8·33

Day.

Lima.

Benzine and kerosene	83·0
Intermediate and lubricating oils with solid hydrocarbons	6·9
Coke	4·1

Redwood.

° C.	
0–150	16·0
150–300	68·0
Residuum	16·0

Mandel & Bourgougnon.

Macksburg.

Benzine	11·0
Kerosene	49·0
Intermediate and lubricating oils with solid hydrocarbons	35·7
Coke	1·8

Redwood.

° C.	
0–150	15·0
150–300	30·0
Residuum	51·3
Paraffin content	4·86

Day.

OKLAHOMA.

Bartlesville.

°C.	Per cent.
0–150	3·0
150–300	39·0
Residuum	58·7
Paraffin content	5·27

Day.

Glenn Pool.

0–150	4·5
150–300	46·0
Residuum	49·9
Paraffin content	5·99

Day.

Madill.

Gasoline	22·0
Kerosene	38·0
Residuum	36·8
Paraffin content	7·41

Day.

PENNSYLVANIA.

Bradford.

Benzine	20·0
Kerosene	50·0
Intermediate and lubricating oils with solid hydrocarbons	25·3
Coke	1·12

Redwood.

Karns City.

Benzine	32·0
Kerosene	64·4

Redwood.

PENNSYLVANIA—*continued.*

Parker (Clarion).

	Per cent.
Benzine	21·0
Kerosene	74·1
Coke	1·36

Redwood.

Stoneham.

Benzine	15·0
Kerosene	75·0
Intermediate and lubricating oils with solid hydrocarbons	6·6
Coke	1·8

Redwood.

Thorn Creek.

Benzine	21·0
Kerosene	74·3
Coke	1·4

Redwood.

Venango Co.

° C.	
0–150	8·55
150–270	42·78
Residuum and loss	48·67

Silliman.

Washington.

Benzine	18·1
Kerosene	71·1
Intermediate and lubricating oils with solid hydrocarbons	0·8
Coke	0·1

Redwood.

PERSIA.

	Per cent.
Kerosene	47·3
Intermediate and lubricating oils with solid hydrocarbons	47·8
Coke	2·7

Redwood.

Tchia-Sourkh.

Benzine	9·4
Kerosene	57·6
Intermediate and lubricating oils with solid hydrocarbons	31·4
Coke	1·1

Redwood.

PERU.

Benzine	11·0
Kerosene	42·0
Intermediate and lubricating oils with solid hydrocarbons	41·5

Redwood.

PHILIPPINE ISLANDS.

Cebu.

	Per cent.	Per cent.
Benzine	12·6	18·4
Kerosene	34·5	29·6
Intermediate and lubricating oils with solid hydrocarbons	46·8	47·1
Coke	3·1	2·9

Redwood.

RUMANIA.

	Per cent.	Per cent.
Benzine	..	28·85
Kerosene	18·9	26·3
Intermediate and lubricating oils with solid hydrocarbons	80·6	42·5
Coke	0·5	1·6

Redwood.

Benzine	1·75	..
Kerosene	54·6	57·25
Intermediate and lubricating oils with solid hydrocarbons	38·3	41·2
Coke	2·1	1·3

Redwood.

Benzine	..	2·0
Kerosene	27·5	25·1
Intermediate and lubricating oils with solid hydrocarbons	64·15	67·6
Coke	2·6	3·1

Redwood.

Benzine	4·5	21·26
Kerosene	32·0	33·86
Intermediate and lubricating oils with solid hydrocarbons	61·2	40·28
Coke	2·3	2·97

Redwood.

Benzine	12·8	9·0
Kerosene	23·1	47·4
Intermediate and lubricating oils with solid hydrocarbons	55·3	41·9
Coke	7·0	0·8

Redwood.

RUMANIA—*continued.*

	Per cent.
Benzine	26·2
Kerosene	19·4
Intermediate and lubricating oils with solid hydrocarbons	48·7
Coke	2·7

Redwood.

Apostolache (Prahova District).

° C.	Per cent.	Per cent.
0–150	28·0	24·6
150–300	32·5	33·2
Residuum	39·5	42·2

Edeleanu.

Baicoi (Prahova District).

	Per cent.	Per cent.	Per cent.
0–150	23·0	50·0	20·4
150–300	41·0	36·0	41·0
Residuum	36·0	14·0	38·6

Edeleanu.

Berca (Buzeu District).

0–150	34·0	16·8
150–300	45·5	49·4
Residuum	20·5	33·8

Edeleanu.

Bustenari (Prahova District).

	Per cent.	Per cent.	Per cent.	Per cent.
0–150	30·7	34·2	16·4	28·2
150–300	32·0	30·0	40·0	35·3
Residuum	37·3	35·8	43·6	35·9

Edeleanu.

RUMANIA—*continued.*

BUSTENARI.

	Per cent.
Crude spirit	30·0
Lamp oil	15·0
Solar oil	10·0
Residuum	42·0

Aisinmann.

CAMPENI (BACAU DISTRICT).

° C.	Per cent.	Per cent.	Per cent.
0–150	10·0	32·6	52·0
150–300	69·5	44·8	40·5
Residuum	20·5	15·6	7·5

Edeleanu.

CAMPINA (PRAHOVA DISTRICT).

0–150	13·4	23·4	29·2
150–300	40·5	34·0	32·6
Residuum	46·1	42·6	38·2

Edeleanu.

COLIBASI (DAMBOVITZA DISTRICT).

0–150	11·5	39·5
150–300	30·0	24·0
Residuum	58·5	36·5

Edeleanu.

GLODENI (DAMBOVITZA DISTRICT).

0–150	10·0	18·0	30·6
150–300	37·5	33·5	31·0
Residuum	52·5	48·5	38·4

Edeleanu.

RUMANIA—*continued.*

Gura-Draganesi (Prahova District).

° C.	Per cent.	Per cent.
0–150	15·2	20·2
150–300	29·5	40·0
Residuum	55·2	39·8

Edeleanu.

Gura-Ocnitei (Dambovitza District).

	Per cent.	Per cent.	Per cent.	Per cent.
0–150	3·7	10·8	16·1	35·0
150–300	31·0	32·2	34·2	30·0
Residuum	65·3	57·0	49·7	35·0

Edeleanu.

Moinesti (Bacau District).

0–150	19·4
150–300	32·2
Residuum	48·4

Edeleanu.

Moreni (Prahova District).

0–150	14·6	25·8
150–300	36·1	32·4
Residuum	49·3	41·8

Edeleanu.

Poiana-Campina (Prahova District).

0–150	7·4	18·4	37·7
150–300	45·5	35·2	30·5
Residuum	47·6	46·4	31·8

Edeleanu.

RUMANIA—*continued*.

Policiori (Buzeu District).

°C.	Per cent.
0–150	23·8
150–300	48·2
Residuum	28·0

Edeleanu.

Sarata-Monteoru (Buzeu District).

	Per cent.	Per cent.	Per cent.
0–150	6·5	14·2	19·0
150–300	41·2	37·6	35·6
Residuum	51·3	48·2	45·4

Edeleanu.

Solontzi (Bacau District).

0–150	9·2	17·4	28·5
150–300	42·0	32·8	30·6
Residuum	48·8	49·8	40·9

Edeleanu.

Tzintea (Prahova District).

0–150	12·6	23·6	31·0
150–300	33·2	38·2	32·0
Residuum	54·2	38·2	37·0

Edeleanu.

RUSSIA.

Anapa.

Benzine	11·2
Kerosene	15·2
Intermediate and lubricating oils with solid hydrocarbons	61·2
Coke	5·8

Redwood.

RUSSIA—*continued.*

Balakhani–Sabuntchi.

	Per cent.
Benzine	6·3
Kerosene	32·5
Intermediate and lubricating oils with solid hydrocarbons	57·1
Coke	3·0

Redwood.

Ferghana (Tchimion).

° C.	
0–150	17·75
150–300	36·70
300	40·40
Residue	3·00
Loss	2·14

Andreiev.

Grozni.

0–100	4·38
100–150	11·25
150–270	25·88
Loss	1·36
Residue	57·13

Kharitchkov.

	Per cent.	Per cent.
Benzine	20·0	19·2
Kerosene	20·0	16·4
Intermediate and lubricating oils with solid hydrocarbons	50·0	56·7
Coke	5·9	5·9

Redwood.

RUSSIA—*continued.*

GROZNI (WEST).

° C.	Per cent.
0–110	12·12
110–150	0·75
150–273	22·0
Residue	66·25
Paraffin content	2·35

Kharitchkov.

KERTCH.

Kerosene	29·0
Intermediate and lubricating oils with solid hydrocarbons	70·5

Redwood.

KUDAKO.

Benzine	12·72
Kerosene	33·67
Intermediate and lubricating oils with solid hydrocarbons	39·6
Coke	01·6

Redwood.

MAIKOP.

° C.	
0–100	5·12
100–150	15·20
150–270	29·0
Loss	0·38
Residue	50·30

Kharitchkov.

0–150	24·56
150–275	29·42
Residue	45·28

Rakusin.

RUSSIA—*continued.*

SURAKHANI.

	Per cent.
Benzine	48·9
Kerosene	43·9

Redwood.

SUVOROVSK.

Benzine	9·5
Kerosene	8·8
Intermediate and lubricating oils with solid hydrocarbons	71·0
Coke	5·7

Redwood.

SPAIN.

VILLAMARTIN.

	Per cent.	Per cent.
Gasoline (0–150° C.)	27·5	19·0
Kerosene (150 300° C.)	53·0	60·0
Residuum	18·4	21·8
Paraffin content	2·52	3·20

Day.

SUMATRA.

Benzine	37·2	26·0
Kerosene	52·0	63·4
Intermediate and lubricating oils with solid hydrocarbons	5·9	7·6
Coke	0·5	0·75

Redwood.

SUMATRA—*continued.*

	Per cent.	Per cent.
Benzine	17·53	19·7
Kerosene	32·8	46·9
Intermediate and lubricating oils with solid hydrocarbons	47·0	31·1
Coke	2·0	0·8

Redwood.

Benzine	23·3	30·4
Kerosene	42·8	51·7
Intermediate and lubricating oils with solid hydrocarbons	28·1	11·2
Coke	1·9	1·7

Redwood.

TEXAS.

BATSON.

Gasoline	6·5
Kerosene	20·4
Solar oil	14·4
Lubricating oil	46·7
Asphalt	6·0

Fenneman.

CORSICANA.

° C.	
0–150	1·0
150–300	46·0
Residuum	51·4
Paraffin content	3·96

Day.

HUMBLE.

0–150	0·5
150–300	40·0
Residuum	58·3

Day.

TEXAS—*continued*.

SARATOGA.

°C.	Per cent.
150–300	18·0
Residuum	81·1

Day.

SOUR LAKE.

0–150	2·0
150–300	32·0
Residuum	65·4

Day.

SPINDLETOP.

0–150	0·5
150–300	37·0
Residuum	62·3

Day

TIMOR.

Kerosene	67·5
Intermediate and lubricating oils with solid hydrocarbons	30·7
Coke	0·5

Redwood.

TRINIDAD.

Benzine	2·0
Kerosene	17·0
Intermediate and lubricating oils with solid hydrocarbons	72·3
Coke	8·6

Redwood.

UTAH.

San Juan Co.

°C.	Per cent.
0–150	10·0
150–300	38·0
Residuum	51·6
Paraffin content	7·31
	Day

WEST VIRGINIA.

Doddridge Co. (Morgansville).

0–150	16·0
150–300	38·0
Residuum	41·2
Paraffin content	5·19
	Day.

Harrison Co. (Shinnston).

0–150	14·0
150–300	40·0
Residuum	44·1
Paraffin content	9·73
	Day.

Pleasants Co. (Maxton Sand, Jefferson).

0–150	0·7
150–300	48·0
Residuum	50·8
Paraffin content	7·72
	Day.

Pleasants Co. (Big Injun Sand, Sugar Valley)

0–150	19·0
150–300	45·0
Residuum	38·0
Paraffin content	5·49
	Day.

WEST VIRGINIA—*continued.*

Ritchie Co. (Cairo).

°C.	Per cent.
0–150	10·0
150–300	39·5
Residuum	48·1
Paraffin content	9·48

Day.

Ritchie Co. (Volcano).

0–150	3·0
150-300	49·0
Residuum	48·0
Paraffin content	6·92

Day.

Wood Co. (Volcano).

0–150	..
150–300	16·0
Residuum	82·4

Day.

WYOMING.

Bonanza.

80–142	10·0
142–303	50·0
Residuum	40·0
Paraffin content	2 4

Slosson.

Lander.

0-150	2·0
150–300	23·5
Residuum	69·9
Paraffin content	91·0
Asphalt	4·02

Day.

WYOMING—*continued*.

SALT CREEK.

°C.	Per cent.
0–150	8·0
150–130	38·0
Residuum	49·3
Paraffin content	4·97

Day.

ZANTE.

Intermediate and lubricating oils with solid hydrocarbons	76·24
Coke	18·44

Redwood.

ANALYSES OF VARIOUS NATURAL GASES.

AUSTRIA.

WELS.

Gas from Well drilled in 1892.

	Per cent.
Methane (CH_4)	95·55
Oxygen (O)	0·62
Nitrogen (N)	2·96
Carbon dioxide (CO_2)	0·17
	99·30

Gas from Well drilled in 1895.

Methane (CH_4)	96·20
Oxygen (O)	0·62
Nitrogen (N)	2·32
Carbon dioxide (CO_2)	0·16
	99·31

M. G. Koch.

GALICIA.

Boryslaw (Ozokerite Mines).

	Per cent.	Per cent.
Methane	38·66	16·63
Heavy hydrocarbons	3·0	2·2
CO_2	0·6	3·0
CO	0·6	Nil.
Hydrogen	13·4	15·2
Nitrogen	43·74	62·57

Zaloziecki.

Tustanowice.

Methane	86·5	83·1
Other hydrocarbons	8·7	8·8
Oxygen	1·0	1·7
Nitrogen	3·8	6·4

Gruskiewicz & Hausmann.

CALIFORNIA.

Los Angeles.

Methane	83·70
Oxygen	2·86
Nitrogen	6·31
CO_2	6·68
CO	0·25
Ethylene	0·20

Cady & MacFarland.

Stockton.

Methane	60·47	62·93
Hydrogen	11·87	11·51
Oxygen	1·00	0·70
Nitrogen	26·66	24·36
CO_2	Trace.	0·50
CO	Trace.	Trace.

Watts.

CANADA.

Tilbury.

	Per cent.
Hydrocarbons (mostly methane)	92·20
CO_2	1·40
CO	0·21
Oxygen	Trace.
Hydrogen	0·40
H_2S	0·20
Nitrogen	5·59

Shuttleworth.

Welland Co.

Methane	96·57
Nitrogen	2·69
H_2S	0·74

Phillips.

ENGLAND.

Heathfield, Sussex.

Methane	93·16
Ethane	2·94
Carbon monoxide	1·00
Nitrogen	2·90
	100·00

H. B. Dixon & W. A. Bone.

Calvert, Buckinghamshire.

Methane (CH_4)	67·0
Ethane (C_2H_6)	12·5
Carbon monoxide (CO)	1·0
Nitrogen	19·5

GERMANY.

Hanover.

	Per cent.
Methane	56·61
CO_2	14·41
Nitrogen	25·12
H_2S	3·18
Petroleum vapour	0·68
	Bunsen.

Pechelbronn.

Methane	77·3
Other hydrocarbons	4·8
CO_2	3·6
CO	3·45
Hydrogen	1·9
Nitrogen	8·95
	Engler.

HUNGARY.

Bassen.

CO_2	0·45
Hydrocarbons (other than methane)	0·30
Methane	83·50
Nitrogen	2·50
Atmospheric air	33·25
	Höfer.

Felsöbajom (Transylvania).

Methane (CH_4)	97·02
Oxygen (O)	0·31
Nitrogen (N)	1·36
Carbon dioxide (CO_2)	0·20
Ethylene (C_2H_4), Ethane (C_2H_6)	1·11
	100·00
	R. Jeller.

HUNGARY—*continued.*

KISSARMAS (TRANSYLVANIA).

	Per cent.
Methane (CH_4)	99·25
Nitrogen	0·75
	100·00

I. Pfeiffer.

Methane (CH_4)	99·00
Hydrogen (H)	0·40
Oxygen (O)	0·40
Nitrogen (N)	0·20
	100·00

R. Schelle.

ILLINOIS.

PITTSFIELD GAS-FIELD, PIKE COUNTY.

Carbon dioxide (CO_2)	0·81
Oxygen (O_2)	3·46
Marsh gas (CH_4)	73·81
Nitrogen (N)	21·92
	100·00

T. E. Savage.
(Ill. State Geol. Surv. Bull. No. 2.)

INDIANA.

Anderson.

	Per cent.
Hydrogen	1·86
Marsh gas	93·07
Olefiant gas	0·49
Carbonic oxide	0·73
Carbonic acid	0·26
Oxygen	0·42
Nitrogen	3·02
Sulphuretted hydrogen	0·15

Kokomo.

Hydrogen	1·42
Marsh gas	94·16
Olefiant gas	0·30
Carbonic oxide	0·55
Carbonic acid	0·29
Oxygen	0·30
Nitrogen	2·80
Sulphuretted hydrogen	0·18

Marion.

Hydrogen	1·20
Marsh gas	93·58
Olefiant gas	0·15
Carbonic oxide	0·60
Carbonic acid	0·30
Oxygen	0·55
Nitrogen	3·42
Sulphuretted hydrogen	0·20

C. C. Howard.

INDIANA—*continued.*

MUNCIE.

	Per cent.
Hydrogen	2·35
Marsh gas	92·67
Olefiant gas	0·25
Carbonic oxide	0·45
Carbonic acid	0·25
Oxygen	0·35
Nitrogen	3·53
Sulphuretted hydrogen	0·15

C. C. Howard.

IOWA.

DAWSON, DALLAS CO.

Hydrocarbons and nitrogen	95·35
CO	2·50
CO_2	1·60
Oxygen	0·55

Leonard.

ITALY.

PIETRAMALA.

	Per cent.	Per cent.
Methane	96·19	97·48
CO_2	1·54	1·75
Nitrogen	2·27	0·77

Fouqué & Gorceix.

SALSOMAGGIORE.

Methane	73·85
Ethane	14·78
Olefines	1·30
Oxygen	0·41
Nitrogen	9·66

Nasini & Salvadori.

KANSAS.

Butler County Gas-Field.

	Per cent.
C_2H_4 (Ethylene)	0·77
CH_4 (Methane)	79·10
C_2H_6 (Ethane)	7·44
Helium	0·25
N_2 (Nitrogen)	12·44
	100·00

Day.

Paola.

Methane	95·20
CO_2	0·33
Ethylene	0·11
CO	1·57
Nitrogen	2·34
Oxygen	0·45

Bailey.

LOUISIANA.

Caddo Gas-Field.

Methane	95·00
Nitrogen	2·56
Carbon dioxide	2·34
Hydrogen	0·00
Carbon monoxide	0·00
Ethylene	0·00
Hydrogen sulphide	0·01
	99·91

C. F. Phillips.

LOUISIANA—*continued.*

Jennings.

	Per cent.
Methane	88·40
Ethane	1·03
Ethylene	0·80
CO	0·40
CO_2	1·80
Nitrogen	5·76
Oxygen	1·81
Helium	Trace.

Cady & MacFarland.

MISSOURI.

Kansas City.

Methane	87·20
Ethane	7·03
Ethylene	1·20
CO	0·20
CO_2	0·60
Nitrogen	3·65
Oxygen	0·10
Helium	0·013

Cady & MacFarland.

NEW YORK.

Fredonia.

Nitrogen	9·54
Carbon dioxide	0·41
Oxygen	Trace.
Paraffins	90·05

C. F. Phillips.

NEW YORK—*continued.*

Olean.

	Per cent.
Methane	96·50
CO_2	0·50
Oxygen	2·00
Olefines	1·00
	Young.

West Bloomfield.

Methane	82·41
CO_2	10·11
N.	4·31
Oxygen	0·23
Olefines	2·94
	Wurtz.

NORTH DAKOTA.

Bottineau.

Hydrogen	0·5
Methane	82·7
Ethylene, etc.	0·2
CO	1·2
Oxygen	3·0
Nitrogen	12·4
	Babcock.

OHIO.

Findlay.

Hydrogen	1·64
Marsh gas	93·35
Olefiant gas	0·35
Carbonic oxide	0·41
Carbonic acid	0·25
Oxygen	0·39
Nitrogen	3·41
Sulphuretted hydrogen	0·20

OHIO—*continued.*

Fostoria.

	Per cent.
Hydrogen	1·89
Marsh gas	92·84
Olefiant gas	0·20
Carbonic oxide	0·55
Carbonic acid	0·20
Oxygen	0·35
Nitrogen	3·82
Sulphuretted hydrogen	0·15

St. Mary's.

Hydrogen	1·74
Marsh gas	93·85
Olefiant gas	0·20
Carbonic oxide	0·44
Carbonic acid	0·23
Oxygen	0·35
Nitrogen	2·98
Sulphuretted hydrogen	0·21

C. C. Howard.

OKLAHOMA.

Blackwell.

Methane	83·40
Ethane	10·31
Ethylene	0·61
Hydrogen	0·33
Nitrogen	5·19
Helium	0·16

Cady & MacFarland.

PENNSYLVANIA.

Kane.

	Per cent.
Nitrogen	9·79
Carbon dioxide	0·20
Oxygen	Trace.
Paraffins	90·01

Lyon's Run (Murraysville).

Nitrogen	2·02
Carbon dioxide	0·28
Oxygen	Trace.
Paraffins	97·30

Sheffield.

Nitrogen	9·06
Carbon dioxide	0·30
Hydrogen	0·00
Oxygen	Trace.
Sulphuretted hydrogen	0·00
Paraffins	90·64

Wilcox.

Nitrogen	9·41
Carbon dioxide	0·21
Oxygen	Trace.
Paraffins	90·38

C. F. Phillips.

RUMANIA.

Berca (Mud Volcano).

Methane	61·11
Ethane	5·75
Ethylene	0·31
CO_2	2·93
Oxygen	3·28
Nitrogen	26·61

Cucu & Starostescu.

RUMANIA—*continued.*

POLICIORI.

	Per cent.
Methane	86·55
Ethylene	0·04
CO_2	8·44
Oxygen	1·45
Nitrogen	3·51

Cucu & Starostescu.

RUSSIA.

AMIRADSCHAN.

Methane	92·43
Olefines	1·63
CO_2	5·23
Oxygen	0·44
Nitrogen	0·27

V. Herr.

BALAKHANI.

	Per cent.	Per cent.	Per cent.
Methane	19·1	11·5	57·7
Other hydrocarbons	1·6	1·0	2·0
CO_2	29·4	1·8	13·6
Oxygen	9·8	18·0	5·6
Nitrogen	40·1	67·7	21·1

V. Herr.

BEREKI.

Methane	65·84
Ethane	19·92
CO_2	12·82

Kharitchkov.

RUSSIA—*continued.*

BIBI-EIBAT.

	Per cent.	Per cent.
Methane	75·2	86·33
Other hydrocarbons	2·3	2·80
CO_2	15·1	9·96
Oxygen	1·5	0·19
Nitrogen	5·9	0·72

V. Herr.

GROZNI.

Methane	49·38	62·0
Other hydrocarbons	15·20	4·8
CO_2	Nil.	18·0
CO	0·09	2·2
Oxygen	0·21	1·4
Nitrogen	1·20	7·0
Hydrogen	33·01	4·0

Kharitchkov.

KERTCH.

Methane	95·39	97·51
CO_2	4·61	2·49

Bunsen.

SURAKHANI.

Methane	87·21	93·3
Olefines	2·05	Nil.
CO_2	3·86	3·0
CO	1·59	Nil.
Nitrogen	5·29	3·7

Kharitchkov.

TAMAN.

Methane	92·24	95·56
Other hydrocarbons	4·26	Nil.
CO_2	3·50	4·44

Bunsen.

SOUTH DAKOTA.

Pierre.

	Per cent.
Methane	73·20
Ethylene	0·25
CO_2	1·14
Nitrogen	21·70
Oxygen	3·19
Helium	Trace.

Cady & MacFarland.

UTAH.

Salt Lake City.

Methane	22·3
Ethane	37·8
Ethylene	0·7
CO	1·2
CO_2	0·8
Hydrogen	16·6
Nitrogen	19·7
Oxygen	0·9

J. Kingsbury.

WEST VIRGINIA.

	1.	2.	3.	4.	5.	6.
CO_2	0·006	0·1	Nil.	Nil.	0·1	Nil.
CO	0·4	0·4	0·4	0·4	0·4	0·5
Oxygen	0·2	0·2	0·2	0·1	0·3	0·3
Hydrogen	Trace.	0·2	Nil.	0·1	0·1	Nil.
Heavy hydrocarbons	0·4	0·2	0·4	0·2	0·1	0·2
Ethane	14·60	14·09	15·09	14·88	14·35	7·65
Methane	80·94	81·60	79·95	80·85	80·70	86·48
Nitrogen	3·46	3·21	3·96	3·47	3·95	4·87

1. Morgantown supply (Big Injun sand).
2. Fairmount supply (Bayard sand), Marion County.
3. Big Injun sand, Lucas Bros., well No. 1, $1\frac{1}{4}$ miles N.-W. of Shinnston.
4. Gordon sand gas, J. B. Cunningham, well No. 1, $3\frac{1}{2}$ miles N.-W. of Shinnston, Harrison Co.
5. Fifth sand gas, Harbut, well No. 1, $\frac{3}{4}$ mile E. of Lumberport, Harrison Co.
6. "Fifty-foot" sand gas, Lucas Bros., well No. 4, 1 mile W. of Shinnston.

Howard.

The valuable and comprehensive table which will be found on the next page, giving analyses of natural and other gases, has been taken from *The Production of Natural Gas in 1909*, U.S. Geological Survey.

ANALYSES OF NATURAL AND MANUFACTURED GASES.

THEIR WEIGHT AND HEATING QUALITY PER 1000 CUBIC FEET; ALSO THEIR SPECIFIC GRAVITY.

Constituent.	Average of Pennsylvania and West Virginia Natural Gas.	Average of Ohio and Indiana Natural Gas.	Average of Kansas Gas.	Average of Coal-Gas.	Average of Water-Gas.	Average of Producer Gas from Bituminous Coal.
Marsh gas, CH_4	80·85	93·60	93·65	40·00	2·00	2·05
Other hydrocarbons	14·00	0·30	0·25	4·00	0·00	0·04
Nitrogen	4·60	3·60	4·80	2·05	2·00	56·26
Carbonic acid, CO_2	0·05	0·20	0·30	0·45	4·00	2·60
Carbonic oxide, CO.	0·40	0·50	1·00	6·00	45·50	27·00
Hydrogen	0·10	1·50	0·00	46·00	45·00	12·00
Hydrogen sulphide	0·00	0·15	0·00	0·00	0·00	0·00
Oxygen	Trace.	0·15	0·00	1·50	1·50	0·05
Total	100·00	100·00	100·00	100·00	100·00	100·00
Pounds in 1000 cu. ft.*	47·50	48·50	49·00	33·00	46·60	75·00
Sp. gr., air being 1	1·624	0·637	0·645	0·435	0·600	0·985
B.Th.U. per 1000 cu. ft.†	1,145,000	1.095,000	1,100,000	755,000	350,000	155,000

* 1000 cubic feet of air at an atmospheric pressure of 14·7 lbs. and at a temperature of 62° F. weighs 76·1 lbs., and is a mechanical mixture of 23 parts of oxygen and 77 parts of nitrogen by weight.

† B.Th.U.—British thermal unit, which indicates the heat necessary to raise 1 lb. of pure water at 39° F. 1 degree F.

ANALYSES OF ASPHALT ROCKS.

CALIFORNIA.

Ventura County.

	Per cent.
Water and volatile oil lost at 217° F.	2·37
Asphaltum	20·00
Ash (fine clay with a little sand and 3 per cent. $CaCO_3$)	77·65

Hilgard.

CANADA.

"Tar Sands."

Water	5·85
Bitumen soluble in CS_2 and benzene	12·42
Sand	81·73

Hoffmann.

FRANCE.

Seyssel.

Water, etc., volatilised at 100° C.	0·40
Bitumen	9·10
Mineral matter	90·50

Durand-Claye.

GERMANY.

Limmer (Dried).

Bitumen soluble in CS_2	8·26
Mineral matter	91·70

Columbia College, N.Y.

Lobsann.

Water, etc., volatilised at 100° C.	3·40
Bituminous matter	11·90
Sulphur	4·99
Mineral matter	79·71

Durand-Claye.

SICILY.

RAGUSA.

	Per cent.
Water, etc., volatilised at 100° C.	0·80
Bituminous matter	8·85
Mineral matter	90·35

Durand-Claye.

SPAIN.

MÄESTU.

Water, etc.	0·40
Bitumen	8·80
Sulphur	Trace.
Mineral matter	90·80

SWITZERLAND.

VAL DE TRAVERS.

Water, etc.	0·35
Bitumen	8·70
Sulphur	0·08
Mineral matter	90·87

Durand-Claye.

BAUMÉ AND SPECIFIC-GRAVITY EQUIVALENTS.

The relation between specific gravity and degrees Baumé adopted by the Bureau of Standards (United States Government Department of Commerce and Labour), and in general use in the United States, for liquids lighter than water is as follows :—

$$\text{Degrees Baumé} = \frac{140}{\text{Specific gravity at } \frac{60^\circ}{60^\circ}\text{ F.}} - 130.$$

or,

$$\text{Specific gravity at } \frac{60^\circ}{60^\circ}\text{ F.} = \frac{140}{130 + \text{Degrees Baumé}}.$$

This relation gives the equivalent values which are stated below.

Baumé.	Sp. Gr.	Baumé.	Sp. Gr.	Baumé.	Sp. Gr.
10	1·0000	37	0·8383	64	0·7216
11	0·9929	38	0·8333	65	0·7179
12	0·9859	39	0·8284	66	0·7143
13	0·9790	40	0·8235	67	0·7106
14	0·9722	41	0·8187	68	0·7071
15	0·9655	42	0·8139	69	0·7035
16	0·9589	43	0·8092	70	0·7000
17	0·9524	44	0·8046	71	0·6965
18	0·9459	45	0·8000	72	0·6931
19	0·9396	46	0·7954	73	0·6896
20	0·9333	47	0·7910	74	0·6863
21	0·9271	48	0·7865	75	0·6829
22	0·9210	49	0·7821	76	0·6796
23	0·9150	50	0·7778	77	0·6763
24	0·9091	51	0·7735	78	0·6731
25	0·9032	52	0·7692	79	0·6698
26	0·8974	53	0·7650	80	0·6667
27	0·8917	54	0·7609	81	0·6635
28	0·8861	55	0·7567	82	0·6604
29	0·8805	56	0·7527	83	0·6573
30	0·8750	57	0·7487	84	0·6542
31	0·8696	58	0·7447	85	0·6512
32	0·8642	59	0·7407	86	0·6481
33	0·8589	60	0·7368	87	0·6452
34	0·8536	61	0·7330	88	0·6422
35	0·8485	62	0·7292	89	0·6393
36	0·8434	63	0·7254	90	0·6364

There is at present in use in the United States another Baumé scale for light liquids, based on the modulus

141·5 instead of 140, but it is believed that the one adopted by the Bureau of Standards will ultimately be universally employed.

TWADDELL'S HYDROMETER.

Twaddell's hydrometer is used only for liquids heavier than water; each degree corresponding to 0·005 of specific gravity, so that 60° = 1·300.

VISCOMETRY.

The determination of the viscosity of an oil is the principal test applied in estimating its lubricating value.

The Redwood viscometer has been adopted by the British Government and the petroleum trade, while the Engler viscometer occupies a similar position in Germany, and the Saybolt viscometer is largely used in the United States. In the first-named the viscosity is determined by noting the time occupied in the outflow of 50 cubic centimetres of the oil at a specified temperature; in Engler's instrument the rate of flow is compared with that of water; and by Saybolt's method the number of seconds for the outflow of the contents of the oil vessel is ascertained.

The relation between the results afforded by these instruments is shown below.

Redwood Viscometer.
Seconds for outflow of 50 c.c. at 70° F.
100.

Engler Viscometer.
Seconds for outflow of 200 c.c. at 20° C.
170.

Saybolt Viscometer.
Seconds for outflow of contents of oil-cup at 70° F.
56.

A modified form of the Redwood instrument has been introduced for testing oil-fuel in accordance with the requirements of the Admiralty specification.

Attention is now being directed to the advantage which attaches to the expression of the results in terms of **absolute viscosity**, as explained in *Lubrication and Lubricants*, by Archbutt and Deeley, 1912.* The formulæ and tables given below, showing the relation between the viscosities determined with the Redwood and Engler instruments respectively and the absolute viscosity are taken from Higgins' paper on "Viscometry," and are based on the results of experiments carried out at the National Physical Laboratory for the International Commission for the Unification of Tests on Petroleum Products.

To deduce the viscosity of an oil from its flow through a capillary tube.

$$\eta t = \frac{R^4 g \rho h T}{8V(L + nR)} = \frac{m \delta V}{8\pi (L + nR) T}$$

where—

ηt = viscosity at temperature $t°$.
R = internal radius of cross section of tube.
$g\rho h$ = pressure under which the oil flows through the tube (due to the head h of liquid of density ρ; $g = 981$ in C.G.S. units).
V = volume of liquid passing through the capillary in time T.
L = length of capillary.
δ = density of liquid at temperature $t°$.
n = coefficient of correction for the "end effect" ($n = 1{\cdot}64$).
m = coefficient of correction term for the kinetic energy of the outflowing oil ($m = 1$).

* C. Griffin & Co., Ltd., London.

To reduce Redwood viscometer readings to viscosity in absolute units.

$$\eta = \left\{ 0{\cdot}00260\mathrm{T} - \frac{1{\cdot}715}{\mathrm{T}} \right\} \delta.$$

To reduce Engler viscometer readings to viscosity in absolute units.

$$\eta = \left\{ 0{\cdot}001435\mathrm{T} - \frac{3{\cdot}22}{\mathrm{T}} \right\} \delta,$$

where—

η = viscosity.
δ = density.
T = time of outflow

Tables showing relation between results on Redwood viscometer and absolute viscosity for four oils.

OIL No. 1.

Temp. ° C.	Density. grms./c.c.	Time of outflow in Redwood Viscometer.	Redwood Viscosity Number.	Calculated Viscosity.	Absolute Viscosity.
10	0·859	59·0	10·3	0·107	0·1075
15	0·856	52·0	9·10	0·087	0·0905
20	0·853	47·4	8·27	0·074	0·077
25	0·849	44·0	7·64	0·064	0·066
30	0·846	41·6	7·20	0·0565	0·057
35	0·843	39·4	6·80	0·0499	0·0498
40	0·839	37·8	6·49	0·0448	0·0438
45	0·836	36·4	6·22	0·0398	0·0387
50	0·833	35·0	5·96	0·0354	0·0343
55	0·830	33·8	5·73	0·0312	0·0304

Oil No. 4.

Temp. ° C.	Density. grms./c.c.	Time of outflow in Redwood Viscometer.	Redwood Viscosity Number.	Calculated Viscosity.	Absolute Viscosity.
30	0·906	239	44·3	0·557	0·540
35	0·903	195	36·0	0·450	0·440
40	0·900	162	29·8	0·370	0·363
45	0·896	137	25·1	0·308	0·304
50	0·893	118	21·5	0·263	0·258
55	0·890	103	18·8	0·224	0·221
60	0·886	90	16·3	0·191	0·187

Oil No. 5.

Temp. ° C.	Density. grms./c.c.	Time of outflow in Redwood Viscometer.	Redwood Viscosity Number.	Calculated Viscosity.	Absolute Viscosity.
15	0·898	586	108	1·367	1·375
20	0·895	416	76·2	0·965	0·920
25	0·892	301	54·9	0·693	0·680
30	0·889	227	41·2	0·518	0·520
35	0·886	176	31·9	0·397	0·400
40	0·882	140	25·3	0·311	0·300

OIL No. 8.

Temp. ° C.	Density. grms./c.c.	Time of outflow in Redwood Viscometer.	Redwood Viscosity Number.	Calculated Viscosity.	Absolute Viscosity.
25	0·946	2080	406	5·12	5·15
30	0·943	1520	293	3·73	3·65
35	0·940	1070	206	2·61	2·68
40	0·936	764	146	1·86	1·97
45	0·933	561	107	1·36	1·44
50	0·930	406	77·5	0·98	1·00

Table showing Comparison between Engler and Redwood Viscometer Results.

T_R.	T_E.	T_E/T_R.
40	73·2	1·83
50	91·5	1·825
75	136·5	1·82
100	181·5	1·815
150	272	1·81
200	362	1·81
500	908	1·81
1000	1815	1·81
5000	9080	1·81

T_R and T_E = corresponding times of outflow on Engler and Redwood viscometers.

Table showing relationship of Engler, Redwood, and Absolute Viscosities.

No. of Oil.	Temperature.	Absolute Viscosity.	Results on Engler Apparatus.			Time of Flow on Redwood Apparatus. T_R	Ratio T_E/T_R.
			Time of Flow, T_E	Specific Viscosity.*	Viscosity.*		
1.	10° C.	0·1075	108·8	7·04	0·108	59·0	1·84
	15	0·0905	95·6	5·76	0·089	51·9	1·84
	20	0·0768	87·8	4·96	0·0765	47·3	1·85
	25	0·0660	82·0	4·36	0·0665	44·0	1·86
	30	0·0571	77·4	3·86	0·0585	41·5	1·86
2.	15	0·216	169·2	12·4	0·200	95·8	1·77
	20	0·168	139·2	9·82	0·157	79·0	1·76
	25	0·135	119·0	8·02	0·127	67·6	1·76
	30	0·111	106·4	6·80	0·107	60·0	1·77
3.	25	0·200	173·0	12·8	0·197	99·6	1·74
	30	0·163	146·2	10·45	0·161	83·4	1·76
	35	0·136	126·0	8·65	0·132	71·6	1·76
	40	0·116	110·6	7·20	0·110	62·6	1·77
	45	0·0985	100·2	6·20	0·095	56·0	1·79

* Obtained from values given in Tabellen zum Englerschen Viskosimeter.

RULES FOR CONVERTING THERMOMETRIC SCALES.

Freezing-point, or 32° Fahrenheit = Zero in Centigrade or Celsius, or Réaumur.

Minus 40° Centigrade = minus 40° Fahrenheit, or 72° of frost.

By use of the following formulæ the conversion of any temperature from one scale to another can be accomplished.

$$\frac{(F^\circ - 32) \times 5}{9} = C^\circ, \qquad \frac{(F^\circ - 32) \times 4}{9} = R^\circ.$$

$$\frac{C^\circ \times 9}{5} + 32 = F^\circ, \qquad \frac{C^\circ \times 4}{5} = R^\circ.$$

$$\frac{R^\circ \times 9}{4} + 32 = F^\circ, \qquad \frac{R^\circ \times 5}{4} = C^\circ.$$

THERMOMETERS.

Comparison of Scales.

Centigrade or Celsius.	Fahrenheit.	Réaumur.	Centigrade or Celsius.	Fahrenheit.	Réaumur.
°	°	°	°	°	°
100	212	80	76	168·8	60·8
99	210·2	79·2	75	167	60
98	208·4	78·4	74	165·2	59·2
97	206·6	77·6	73	163·4	58·4
96	204·8	76·8	72	161·6	57·6
95	203	76	71	159·8	56·8
94	201·2	75·2	70	158	56
93	199·4	74·4	69	156·2	55·2
92	197·6	73·6	68	154·4	54·4
91	195·8	72·8	67	152·6	53·6
90	194	72	66	150·8	52·8
89	192·2	71·2	65	149	52
88	190·4	70·4	64	147·2	51·2
87	188·6	69·6	63	145·4	50·4
86	186·8	68·8	62	143·6	49·6
85	185	68	61	141·8	48·8
84	183·2	67·2	60	140	48
83	181·4	66·4	59	138·2	47·2
82	179·6	65·6	58	136·4	46·4
81	177·8	64·8	57	134·6	45·6
80	176	64	56	132·8	44·8
79	174·2	63·2	55	131	44
78	172·4	62·4	54	129·2	43·2
77	170·6	61·6	53	127·4	42·4

THERMOMETERS—*continued.*

Comparison of Scales—*continued.*

Centigrade or Celsius.	Fahrenheit.	Réaumur.	Centigrade or Celsius.	Fahrenheit.	Réaumur.
°	°	°	°	°	°
52	125·6	41·6	28	82·4	22·4
51	123·8	40·8	27	80·6	21·6
50	122	40	26	78·8	20·8
49	120·2	39·2	25	77	20
48	118·4	38·4	24	75·2	19·2
47	116·6	37·6	23	73·4	18·4
46	114·8	36·8	22	71·5	17·6
45	113	36	21	69·8	16·8
44	111·2	35·2	20	68	16
43	109·4	34·4	19	66·2	15·2
42	107·6	33·6	18	64·4	14·4
41	105·8	32·8	17	62·6	13·6
40	104	32	16	60·3	12·8
39	102·2	31·2	15	59	12
38	100·4	30·4	14	57·2	11·2
37	98·6	29·6	13	55·4	10·4
36	96·8	28·8	12	53·6	9·6
35	95	28	11	51·8	8·8
34	93·2	27·2	10	50	8
33	91·4	26·4	9	48·2	7·2
32	89·6	25·6	8	46·4	6·4
31	87·8	24·8	7	44·6	5·6
30	86	24	6	42·8	4·8
29	84·2	23·2	5	41	4

THERMOMETERS—*continued.*

Comparison of Scales—*continued.*

Centigrade or Celsius.	Fahrenheit.	Réaumur.	Centigrade or Celsius.	Fahrenheit.	Réaumur.
°	°	°	°	°	°
4	39·2	3·2		Minus.	
3	37·4	2·4	18	0·4	14·4
2	35·6	1·6	19	2·2	15·2
1	33·8	0·8	20	4	16
0	32	0	21	5·8	16·8
			22	7·6	17·6
Minus.		Minus.	23	9·4	18·4
1	30·2	0·8	24	11·2	19·2
2	28·4	1·6	25	13	20
3	26·6	2·4	26	14·8	20·8
4	24·8	3·2	27	16·6	21·6
5	23	4	28	18·4	22·4
6	21·2	4·8	29	20·2	23·2
7	19·4	5·6	30	22	24
8	17·6	6·4	31	23·8	24·8
9	15·8	7·2	32	25·6	25·6
10	14	8	33	27·4	26·4
11	12·2	8·8	34	29·2	27·2
12	10·4	9·6	35	31	28
13	8·6	10·4	36	32·8	28·8
14	6·8	11·2	37	34·6	29·6
15	5	12	38	36·4	30·4
16	3·2	12·8	39	38·2	31·2
17	1·4	13·6	40	40	32

BRITISH THERMAL UNIT.

The British Thermal Unit (B.Th.U.), or unit of heat, is the quantity of heat necessary to raise one pound of pure water one degree F., or, more correctly, from 39·1° to 40·1°.

CALORIE.

The calorie is the heat unit used on the Continent with the metrical system, and is the amount of heat required to raise, in the case of the small calorie, 1 gram of water 1° C., and in the case of the large calorie, 1 kilogram of water 1° C.

The ratios of English and French units are as follows :—

1 calorie	= ·001 great calorie.
1 great calorie	= 3·968 B.Th.U.
1 B.Th.U.	= ·252 great calorie.
1 great calorie	= 427 kilog.-metres.

MECHANICAL EQUIVALENT OF HEAT.

The number of units of mechanical work equivalent to one unit of heat is generally called the mechanical equivalent of heat, or Joule's equivalent, and is denoted by the letter J. Its numerical value depends on the units employed for heat and mechanical energy respectively. The values of the equivalent in terms of the units most commonly employed at the present time are as follows :—

777 foot-lbs. (lat. 45°)	= 1 B.Th.U. (lb.-deg. Fahr.)
1399 foot-lbs. ,,	= 1 lb.-deg. C.
426·3 kilogrammetres	= 1 kilogram-deg. C. or kilocalorie.
426·3 grammetres	= 1 gram-deg. C. or calorie.
4·180 joules	= 1 gram-deg. C. or calorie.

Encycl. Brit. (11th ed.).

CALORIFIC POWER OF VARIOUS FUELS.

Fuel.	Pounds of Water per Unit of Fuel.	Calories per Unit of Fuel.	Authority.
GASEOUS.*			
Natural gas—			
Houston, Pa.	107·38	..	Phillips.†
Fredonia, N.Y.	133·30	..	"
Ohio and Indiana	..	109,500 B.T.U.	Hill.
Kansas	..	110,000 B.T.U.	"
Coal gas	..	75,500 B.T.U.	"
LIQUID.			
Petroleum—			
Pennsylvania	15·30	10,672	Veith.
Balakhani	..	11,700	"
Fuel oil—			
Burma	..	10,794	Redwood.
Borneo	..	10,371	"
Texas	..	10,957	"
California	14·20	..	Oliphant.
Kerosene—			
Russian	..	11,260	Redwood.
Petroleum spirit—			
American	..	12,220	"
SOLID.			
Coal	..	7,500	Veith.
Anthracite, Pa.	9·8	..	Oliphant.
Pittsburgh lump.	10·0	..	"
Cardiff lump.	10·0	..	"
Coke	..	6,500	Veith.
Peat	..	4,500	"
Wood	..	2,800	"

* Unit=100 cubic feet.
† By calculation from analyses.

THEORETICAL COMPARATIVE VALUES OF PETROLEUM FUEL AND COAL.

Fuel.	Specific Gravity at 32° F.	Heating Power in B.Th.U.	Pounds of Water evaporated theoretically, per lb. of Fuel.	
			From and at 212° F.	At 8½ atmospheres, effective pressure.
Pennsylvania heavy crude oil	0·886	20,736	21·48	17·8
Caucasian light crude oil .	0·884	22,027	22·79	18·9
Caucasian heavy crude oil .	0·938	20,138	20·85	17·3
Petroleum refuse . .	0·928	19,832	20·53	17·1
Good English coal, mean of 98 samples . .	1·380	14,112	14·61	12·16

Booth.

CALORIFIC VALUES OF VARIOUS OILS.

Country.	Field.	Calories.	Authority.
Borneo (fuel oil)	..	10,371	Redwood.
Burma (fuel oil)	..	10,924	,,
California .	Coalinga (heavy)	10,356	Allen.
	,, (light)	10,748	,,
,, (fuel oil)	..	10,400	Redwood.
Galicia . .	Boryslaw (crude)	11,064*	Wielezynski.
	,, (masut)	10,845*	,,
	Kosmacz (crude)	11,092*	,,
	,, (masut)	10,852*	,,
	Mraznica (crude)	10,544*	,,
	Potok (crude)	10,866*	,,
	Urycz (crude)	11,092*	,,
	,, (masut)	10,675*	,,
Java . .	..	10,831	Redwood.
Mexico (fuel oil)	..	10,460	,,
Pennsylvania (light)	..	9,963	Veith.
Pennsylvania (heavy)	..	10,672	,,
Persia (fuel oil) .	..	10,840	Redwood.
Rumania (fuel oil)	..	10,710	,,
Russia . .	Balakhani.	11,700	Veith.
	Romani.	11,207*	Wielezynski
(Kerosene)	..	11,260	Redwood.
(Solar oil)	..	10,920	,,
Texas (crude) .	..	11,604*	Wielezynski.
(crude) .	..	10,957	Redwood.
	Sour Lake.	10,201	Univ. Texas.
	Spindletop.	10,992	,,
Trinidad (fuel oil)	..	10,480	Redwood.
West Virginia (heavy)	..	10,180	Veith.
West Virginia (light)	..	10,223	,,
Wyoming (Lander)	..	10,883	Slosson and Colburn.

* Calculated according to Mendeleeff's formula.

Calorific Values of Texas Crude Oils.

Source of Sample.	Calories.	B.Th.U.
Lucas well, Spindletop, Jefferson Co.	10,874	19,574
Higgins Oil and Fuel Co., Spindletop, Jefferson Co.	10,992	19,785
Sour Lake, Hardin Co.	10,201	18,362
Sour Lake, Hardin Co.	10,305	18,694
North-east of Fort Stockton, Pecos Co.	9,655	17,387
Near Dunlay, Medina Co.	9,372	16,807
Dulling wells, Bexar Co.	8,531	15,356
Walsh Tract, Bexar Co.	9,177	16,518

Univ. Texas.

SPECIFIC HEAT.

The specific heat is the number of heat-units required to raise the unit of mass of a given substance through 1° of temperature. For solids, water is taken as the standard—that is, its specific heat is unity.

Table giving the Specific Heat of certain Crude Oils as determined by Mabery and Goldstein.

	Specific Heat.	Specific Gravity.
California	0·3980	0·9600
Texas	0·4009	0·9466
Texas (Lucas well)	0·4315	0·9200
Russia	0·4355	0·9079
Wyoming	0·4323	0·8816
Japan	0·4532	0·8622
Pennsylvania	0·5000	0·8095
Ohio	0·4951	..

Table giving Specific Heat of Rumanian Crude Oils as determined by Scheller and Gheorgiu.

Policiori	0·4724
Campina	0·4675
,,	0·4667
Bustenari	0·4625

Specific Heat between 12° and 25° C. of certain Typical Samples of Petroleum Products.

	Sp. Gr. (at 15° C.)	Sp. Ht.	Sp. Gr. × Sp. Ht.
Motor Spirit.			
Anglo-American Oil Company, Ltd. — Heavy ("Taxibus")	0·7375	0·465	0·343
Anglo-American Oil Company, Ltd. — Light ("Pratt's Perfection")	0·7240	0·483	0·350
Asiatic Petroleum Company, Ltd. — "Shell," heavy ("760 Benzine")	0·7675	0·450	0·346
Asiatic Petroleum Company, Ltd. — "Shell," light ("720 Benzine")	0·7215	0·490	0·352
Kerosene.			
Anglo-American Oil Company, Ltd.—Water white	0·799	0·457	0·365
Anglo-American Oil Co., Ltd.—Standard white	0·8035	0·450	0·362
Russian	0·8248	0·435	0·358
Rumanian	0·8127	0·444	0·361
Shale oil (Young's paraffin oil)	0·804	0·472	0·379
Fuel Oil.			
Russian	0·914	0·448	..
Burma	0·897	0·433	..
Texas	0·927	0·436	..

J. S. S. Brame.

THE MORE IMPORTANT HYDROCARBONS OF PETROLEUM.

1. The Paraffins.

General formula C_nH_{2n+2}.

	Name.	Formula.	Boiling-point. °C.	Sp. Gr.
Gaseous.	Methane	CH_4	−164	..
	Ethane	C_2H_6	..	..
	Propane	C_3H_8	− 38	..
	Butane	C_4H_{10}	+ 1	..
Liquid.	Pentane	C_5H_{12}	38	0·628
	Hextane	C_6H_{14}	69	0·664
	Heptane	C_7H_{16}	97·5	0·699
	Octane	C_8H_{18}	125	0·703
	Nonane	C_9H_{20}	136	0·741
	Decane	$C_{10}H_{22}$	158	0·757
	Endecane	$C_{11}H_{24}$	182	0·765
	Dodecane	$C_{12}H_{26}$	198	0·776
	Tridecane	$C_{13}H_{28}$	216	0·792
	Tetradecane	$C_{14}H_{30}$	238	..
	Pentadecane	$C_{15}H_{32}$	258	..
	Hexadecane	$C_{16}H_{34}$	280	..
	Octodecane	$C_{18}H_{38}$	..	..
	Nonadecane	$C_{19}H_{40}$	..	..
	Eicosane	$C_{20}H_{42}$	..	..
	Tricosane	$C_{23}H_{48}$	..	..
Solid.	Heptacosane (myricyl)	$C_{27}H_{56}$	..	..
	Triacontane (ceryl)	$C_{30}H_{62}$	..	..

IMPORTANT HYDROCARBONS OF PETROLEUM—*continued.*

2. THE OLEFINES.

General formula C_nH_{2n}.

Namo.	Formula.
Ethylene	C_2H_4
Propylene	C_3H_6
Butylene	C_4H_8
Amylene	C_5H_{10}
Hexylene	C_6H_{12}
Heptylene	C_7H_{14}
Octylene	C_8H_{16}
Nonylene	C_9H_{18}
Decatylene	$C_{10}H_{20}$
Endecatylene	$C_{11}H_{22}$
Dodecatylene	$C_{12}H_{24}$
Decatriline	$C_{13}H_{26}$
Cetene	$C_{16}H_{32}$
Cerotene	$C_{27}H_{54}$
Melene	$C_{30}H_{60}$

3. THE NAPHTHENES.

General formula $C_nH_{2n-6}+H_6$.

Name.	Formula.	Boiling-point. °C.	Sp. Gr.
Trimethylene or Cyclopropane	C_3H_6	..	..
Tetramethylene or Cyclobutane	C_4H_8	..	..
Pentamethylene or Cyclopentane	C_5H_{10}	..	..
Hexamethylene or Cyclohexane	C_6H_{12}	69	0·7539
Heptamethylene or Cycloheptane	C_7H_{14}	97	0·772
	C_8H_{16}	122 to 124	0·7835
	C_9H_{18}	135 to 136	0·7808
	$C_{10}H_{20}$	160 to 162	0·7808

IMPORTANT HYDROCARBONS OF PETROLEUM—*continued.*

4. THE ACETYLENES.

General formula C_nH_{2n-2}

Name.	Formula.	Boiling-point. °C.
Acetylene . . .	C_2H_2	Gas.
Methyl acetylene or propine .	C_3H_4	Gas.
Ethyl acetylene or butine .	C_4H_6	18
Propyl acetylene or pentine .	C_5H_8	48–50

5. THE AROMATIC HYDROCARBONS.

Name.	Formula.	Boiling- or Melting-point. °C.	Sp. Gr.
Benzene . .	C_6H_6	80·5	0·814
Naphthalene .	$C_{10}H_8$	79	. .

The Appalachian oils consist mainly of members of the paraffin group; Baku oil of naphthenes; shale oil very largely of olefines.

COEFFICIENT OF EXPANSION.

The rate of expansion of petroleum products under the influence of increased temperature varies with the specific gravity.

In the case of kerosene, the practice of the trade in the United Kingdom is to add to or subtract from the specific gravity at 60° F. 0·0004 for every 1° F. above or below that temperature.

According to the authors' experience, the following corrections for each 1° F. should in practice be made :—

For products lighter than kerosene, 0·00040 to 0·00048.
,, kerosene, 0·00040.
,, gas oils, 0·00036.
,, lubricating oils, 0·00034.

Examples—

If the specific gravity of a kerosene at 60° F. is 0·790, what will it be (*a*) at 85° F. ; (*b*) at 32° F.

(*a*) Difference = 25°.

Sp. gr. at 60° = 0·790
Subtract 0·0004 × 25, 0·010

Sp. gr. at 85° = 0·780

(*b*) Difference = 28°.

Sp. gr. at 60° = 0·790
Add 0·0004 × 28, 0·0112

Sp. gr. at 32° = 0·8012

[Table.

CORRECTION OF APPARENT FLASHING-POINTS TO THE

	Flash-point at Standard Atmospheric Pressure.	Flashing-points (Abel-Pensky test) in degrees Centigrade,											
Bar.	760.	650.	655.	660.	665.	670.	675.	680.	685.	690.	695.	700.	705.
Flashing-points.	19·0	15·5	15·6	15·7	15·8	15·9	16·1	16·2	16·4	16·6	16·7	16·9	17·1
	19·5	16·0	16·1	16·2	16·3	16·4	16·6	16·7	16·9	17·1	17·2	17·4	17·6
	20·0	16·5	16·6	16·7	16·8	16·9	17·1	17·2	17·4	17·6	17·7	17·9	18·1
	20·5	17·0	17·1	17·2	17·3	17·4	17·6	17·7	17·9	18·1	18·2	18·4	18·6
	21·0	17·5	17·6	17·7	17·8	17·9	18·1	18·2	18·4	18·6	18·7	18·9	19·1
	21·5	18·0	18·1	18·2	18·3	18·4	18·6	18·7	18·9	19·1	19·2	19·4	19·6
	22·0	18·5	18·6	18·7	18·8	18·9	19·1	19·2	19·4	19·6	19·7	19·9	20·1
	22·5	19·0	19·1	19·2	19·3	19·4	19·6	19·7	19·9	20·1	20·2	20·4	20·6
	23·0	19·5	19·6	19·7	19·8	19·9	20·1	20·2	20·4	20·6	20·7	20·9	21·1
	23·5	20·0	20·1	20·2	20·3	20·4	20·6	20·7	20·9	21·1	21·2	21·4	21·6
	24·0	20·5	20·6	20·7	20·8	20·9	21·1	21·2	21·4	21·6	21·7	21·9	22·1
	24·5	21·0	21·1	21·2	21·3	21·4	21·6	21·7	21·9	22·1	22·2	22·4	22·6
	25·0	21·5	21·6	21·7	21·8	21·9	22·1	22·2	22·4	22·6	22·7	22·9	23·1

NORMAL BAROMETRIC PRESSURE OF 760 MILLIMETRES.

corresponding to various Barometric Readings in mm.

710.	715.	720.	725.	730.	735.	740.	745.	750.	755.	765.	770.	775.	780.	785.
17·3	17·4	17·6	17·8	18·0	18·1	18·3	18·5	18·7	18·8	19·2	19·4	19·5	19·7	19·9
17·8	17·9	18·1	18·3	18·5	18·6	18·8	19·0	19·2	19·3	19·7	19·9	20·0	20·2	20·4
18·3	18·4	18·6	18·8	19·0	19·1	19·3	19·5	19·7	19·8	20·2	20·4	20·5	20·7	20·9
18·8	18·9	19·1	19·3	19·5	19·6	19·8	20·0	20·2	20·3	20·7	20·9	21·0	21·2	21·4
19·3	19·4	19·6	19·8	20·0	20·1	20·3	20·5	20·7	20·8	21·2	21·4	21·5	21·7	21·9
19·8	19·9	20·1	20·3	20·5	20·6	20·8	21·0	21·2	21·3	21·7	21·9	22·0	22·2	22·4
20·3	20·4	20·6	20·8	21·0	21·1	21·3	21·5	21·7	21·8	22·2	22·4	22·5	22·7	22·9
20·8	20·9	21·1	21·3	21·5	21·6	21·8	22·0	22·2	22·3	22·7	22·9	23·0	23·2	23·4
21·3	21·4	21·6	21·8	22·0	22·1	22·3	22·5	22·7	22·8	23·2	23·4	23·5	23·7	23·9
21·8	21·9	22·1	22·3	22·5	22·6	22·8	23·0	23·2	23·3	23·7	23·9	24·0	24·2	24·4
22·3	22·4	22·6	22·8	23·0	23·1	23·3	23·5	23·7	23·8	24·2	24·4	24·5	24·7	24·9
22·8	22·9	23·1	23·3	23·5	23·6	23·8	24·0	24·2	24·3	24·7	24·9	25·0	25·2	25·4
23·3	23·4	23·6	23·8	24·0	24·1	24·3	24·5	24·7	24·8	25·2	25·4	25·5	25·7	25·9

PARTICULARS OF OIL-SHALES.

CANADA.

Results of distillation of oil-shale from Westmoreland County, New Brunswick.

Date, 1908.	Weight of Shale used.		Crude Oil.		Yield per Ton.	
	Tons	Cwts.	Gallons.	Sp. Gr.	Crude Oil. Gallons.	Ammonium Sulphate, Lbs.
July 25th*	2	4	95·85	0·885	43·57	58·55
,, 26th*	2	6	99·45	0·907	43·24	60·51
,, 27th	2	0	74·44	0·920	37·22	75·38
,, 28th	2	5	86·13	0·917	38·28	70·62
,, 29th	2	7	90·37	0·911	38·88	70·01
,, 30th	2	3	81·80	0·920	38·04	83·18
,, 31st	2	5	84·63	0·916	37·61	67·46
Aug. 1st	2	3	96·87	0·918	45·06	82·93
,, 2nd	2	3	84·32	0·921	39·22	79·58
,, 3rd	2	4	89·42	0·927	40·64	81·88
,, 4th	2	4	79·56	0·918	34·59	49·27
,, 5th	2	3	86·75	0·910	40·35	55·47†
,, 6th	2	5	88·70	0·922	39·42	82·81
,, 7th	2	3	87·38	0·918	40·64	100·69‡
,, 8th	2	4	88·43	0·921	40·19	62·45
,, 9th	2	3	95·72	0·918	44·52	79·63
,, 10th	2	3	91·28	0·911	42·46	81·31
,, 11th	2	0	79·90	0·925	39·95	71·14
,, 12th	2	0	87·58	0·925	43·79	85·03
	36	15	1473·28	..	40·09	76·94

* Not included in average, as shale in previous test was not all out of retort until July 26.

† Condenser chest choked. ‡ Condenser cleared.

C. Baskerville.
(*Eng. and Min. J.*, 1909.)

ENGLAND.

Kimmeridge (Blackstone).

	Per cent.
Oily and solid volatile matters	39
Gas, water, and ammonia, etc.	18
Coke	43

Crude oil yields :—

Naphtha	2·3
Heavy oil (1·9 per cent. paraffin)	36·7

FRANCE.

Autun.

6·15 litres of crude oil from 1 hectolitre (about 105 kilos.) of shale.

Buxière les Mines.

6·40 litres per hectolitre.

Crude French shale-oil has a specific gravity of 0·912 and yields :—

	Per cent.
Spirit	3·5
Burning oil	19·06
Gas oil	23·13
Pale oil	8·22
Lubricating oil, No. 2	6·45
,, ,, No. 1	9·95
Cylinder oil	1·07
Refined paraffin	2·68
Still grease	3·37
Coke	3·47

NEW SOUTH WALES.

Capertee.

Specific gravity of shale	1·104
Volatile matters (per cent.)	74·70

Megalong.

Specific gravity of shale	1·214
Volatile matters (per cent.)	62·29

NEW ZEALAND.

Locality.	Percentage of Volatile Matter.
D'Urville Island	81·79
Mongonui ,,	75·20
Chatham Islands	66·43
,, ,,	64·67

SCOTLAND.

Seam.	Yield per Ton.	
	Ammonium Sulphate.	Crude Oil.
	Lbs.	Gallons.
Fells	25 to 35	36 to 40
Broxburn	30 to 40	28 to 33
Dunnet	..	15 to 30
Curly	60 to 70	19
Pumpherston	50 to 60	16 to 32

SCOTLAND—*continued.*

Yield from Crude Oil.

The results given below were obtained in 1895, but the percentages are often varied to suit market requirements.

Young's Paraffin Light and Mineral Oil Co.

	Per cent.
Gasoline and naphtha	6·09
Burning oils	31·84
Intermediate and heavy oils	23·97
Paraffin scale	13·53
Loss	24·57
	100·00

Broxburn Oil Company.

Naphtha		3·00
Burning oil	30·0	
Gas-oil	9·0	
		39·00
Lubricating oil		18·00
Paraffin		10·00
Loss		30·00
		100·00

SERVIA.

Alexinatz.

Yield of crude oil per ton, 43–45½ gallons.

	Percentage Yield from Crude Oil.
Burning oil	30·0
Intermediate oil	4·5
Lubricating oil	15·5
Paraffin scale	14·3

SPAIN.

RIBES ALBES.

Specific gravity of shale . . . 1·81

SANCHILS.

Specific gravity of shale . . . 1·70

DESTRUCTIVE DISTILLATION: DEFINITION OF.

Destructive distillation is the decomposition of a substance in a closed vessel in such a manner as to obtain liquid products. By a product is meant a body not originally present in the substance distilled. A body merely extracted without change by distillation is termed an educt.

E. J. Mills.

TO ASCERTAIN THE PERCENTAGE COMPOSITION OF CHEMICAL SUBSTANCES.

Find the formula for the substance, then find the total molecular weight. The weight of each separate element of the body multiplied by 100 and divided by the total molecular weight will give the percentage composition.

Example—

Required the percentage composition of sulphuric acid, the formula for which is H_2SO_4.

$$H_2 = 2 \qquad \frac{2 \times 100}{98} = 2{\cdot}04$$

$$S = 32 \qquad \frac{32 \times 100}{98} = 32{\cdot}65$$

$$O_4 = \underline{64} \qquad \frac{64 \times 100}{98} = \underline{65{\cdot}31}$$

$$\text{Molecular weight} = \underline{98} \qquad \qquad \underline{100{\cdot}00}$$

SULPHURETTED HYDROGEN.

Formula H_2S.
Molecular weight 34.

H_2S is a colourless gas having a smell of rotten eggs. It is soluble in water and burns with a pale bluish flame. When inhaled it is not irritant, but is powerfully narcotic. It is, however, extremely poisonous, and the inhalation of air containing only a small percentage causes death. Oil-wells sometimes yield large quantities of this gas, and in such cases precautions should be taken to ensure the safety of the men working on them. Sulphuretted hydrogen is of common occurrence in "sulphur springs."

This gas is also known as sulphydric acid and hydrosulphuric acid.

LIGHT CARBURETTED HYDROGEN.

Formula CH_4.
Molecular weight 16.

Light carburetted hydrogen is also known as marsh gas and methylic hydride. Marsh gas is colourless, odourless, and tasteless, and is only slightly soluble in water. This gas burns with a pale yellowish flame of little luminosity.

HEAVY CARBURETTED HYDROGEN

Formula C_2H_4.
Molecular weight 28.

Heavy carburetted hydrogen, also known as olefiant gas and ethylene, is a colourless gas having a sweetish taste. It is but slightly soluble in water and burns with a highly luminous flame.

SULPHURIC ACID OF COMMERCE.

The product most commonly demanded is B.O.V. (brown oil of vitriol), which contains about 80 per cent.

of sulphuric acid and owes its brown colour to impurities such as arsenic, iron, and the like. Purer and concentrated acid of 96 per cent. strength, and "fuming" sulphuric acid consisting of 100 per cent. sulphuric acid with the addition of varying quantities of sulphur trioxide ("oleum"), are also articles of commerce.

CAUSTIC SODA.

This product consists chiefly of sodium hydroxide, with varying quantities of sodium carbonate. The quality of the product is indicated by the percentage of sodium oxide, Na_2O, which it contains, the most usual strength being 72 to 74 per cent. Caustic soda in the liquid form, containing 32 per cent. Na_2O, and powdered caustic soda of 99·9 per cent. purity, made by electrolytic means, are also articles of commerce.

SULPHUR DIOXIDE.

Formula SO_2.
Molecular weight 64.

Sulphur dioxide is a colourless gas, having the peculiar suffocating odour of burning brimstone; it instantly extinguishes flame, and is quite irrespirable. It is easily liquefied and is sold in "syphons" in this form. Liquid sulphur dioxide at low temperatures has the property of taking into solution unsaturated and aromatic hydrocarbons, and is employed in the Edeleanu process of petroleum refining in removing these compounds, the paraffin hydrocarbons remaining undissolved.

FULLER'S EARTH.

Fuller's earth is a greenish or yellowish earthy material somewhat resembling clay in appearance and feel, but crumbling into mud with water. In composition it is a hydrated silicate of alumina with an admixture of iron,

magnesia, and other salts. It occurs sometimes in beds among sedimentary rocks, sometimes as a product of the decomposition of igneous masses.

The average percentage composition of Florida fuller's earth is as follows :—

Silica	56·53
Alumina	11·57
Magnesia	6·29
Iron oxide	3·32
Calcium oxide	3·06
Water	17·95
Alkalis, etc.	1·28
	100·00

Fuller's earth is extensively employed for decolorising various oils. The method usually adopted is to employ the material as a filtering agent. After use the earth is regenerated by being calcined. In large refineries special plant is employed for this purpose, but where only small quantities are used it is a common practice to roast it in open hearth kilns. As a rule no fuel is required, as the oil in the earth, on being ignited, is sufficient for the purpose. Before using the regenerated material it is usual to add to it a certain amount of unused fuller's earth.

BAUXITE.

Bauxite is an impure hydrated oxide of aluminium of a reddish colour. It is found at Baux (France), whence it derives its name, and in Ireland, India, the United States (southern), and elsewhere. When thoroughly dehydrated it is a very effective decolorising agent for all mineral oils and waxes. After such use it can easily be rendered active again, the revivified substance being as effective as the original.

LITHARGE.

Formula PbO.

When lead, one of its oxides, or the carbonate or nitrate, is heated in air, the monoxide is formed. At a moderate temperature a yellowish powder (massicot) is obtained; but if the heat is sufficiently great to cause fusion, the oxide on cooling solidifies to the yellow crystalline material known commercially as litharge.

OZOKERITE.

Natural paraffin, varying from a very soft substance to a black material as hard as gypsum.

Sp. gr. 0·85 to 0·95, melting-point 58° to 100° C. Soluble in ether, benzene, petroleum, turpentine, chloroform, CS_2, etc.

Refined ozokerite is largely known as ceresine.

VASELINE.

Colourless or pale yellow, translucent, fluorescent, amorphous, no taste or smell, soluble in chloroform, benzene, CS_2, and turpentine, also in warm ether and hot alcohol.

Melting-point 40° to 50° C., sp. gr. at 100° C., 0·803 or higher.

STANDARD CANDLE-POWER.

The British standard unit of light for photometric purposes was formerly defined as that given by a sperm candle, "short 6," burning 120 grains per hour.

A spermaceti candle, 0·85 inch in diameter, burns about 1 inch per hour.

The British candle-power is now measured by means of the Pentane standard, which gives a light of 10 candle-power.

Part IV.

PRODUCTION.

PRODUCTION.

Within the limits of this work it is impossible to deal with the whole of the drilling systems in vogue, or to do more than indicate the standard types of engines, boilers, and other machinery in common use. It may be said that twenty years ago there were practically only two systems of drilling extensively used, viz. the Canadian and the American, although, even then, there were many other methods known and used in drilling for oil. To-day the Canadian system (now usually known as the Canadian-Galician), the American cable system, and the Rotary system are those generally employed. It is only these, therefore, which will be described in the following pages, though the authors fully recognise that there are other excellent methods of drilling.

The Canadian or Canadian-Galician and the American are both percussion systems of drilling, the strata being perforated and broken up by successive blows of a chisel-shaped *bit*, the diameter of which determines the diameter of the bore-hole. The bit is screwed into a long, heavy iron rod, termed the *auger-stem*, and this in turn is similarly attached to the *jars*, which may be likened to a couple of elongated and flattened links of a chain constructed to slide freely within each other. The function of this device is to give the drill a sharp jar on the upward stroke, thus loosening the bit if it has become jammed in the rock. Above the jars is another long, heavy iron rod called the *sinker-bar*. The string of tools thus constituted is suspended from one

end of a massive beam, termed the *walking-beam*, pivoted in the centre on a vertical post. The other end of this beam is connected by a rod, termed the *pitman*, with a crank on a horizontal shaft, driven by a steam-engine through the medium of a belt. Oscillating motion is thus imparted to the beam, and vertical reciprocating motion to the string of tools.

In the Canadian system of drilling the string of tools is gradually lowered as the drilling progresses, by the successive insertion of wooden or iron rods between the tools and the walking-beam, whilst in the Canadian-Galician system a wire-rope is now largely employed in place of the rods, and in the American system the tools are suspended by a manila cable. The rods are attached to the walking-beam by a chain passing over a small windlass, termed a *slipper-out*, and the cable is held by clamps attached to the *temper-screw* at the end of the walking-beam. The slipper-out and the temper-screw respectively provide in the two systems the means of gradually lowering the tools as the depth of the borehole increases.

From time to time it is necessary to withdraw the string of tools from the well in order to remove the detritus, and for this purpose a pyramidal *derrick*, usually of wood, is erected on the site of the well. The dimensions of the derrick vary according to circumstances, a usual size being 20 feet square at the base and 70 feet in height. In raising the tools the wire rope in the Canadian-Galician system, or the manila cable in the American system, is passed over a pulley at the summit of the derrick to a wooden windlass fitted at one side of the derrick, the windlass being driven, through the medium of a belt, by the same engine that imparts motion to the walking-beam. When a continuous string of rods is employed, it is necessary to disconnect these rods one by one as the tools are withdrawn.

Water is introduced into the borehole as the drilling

progresses, so that the detritus is reduced to the condition of mud; and this is removed, when the tools have been withdrawn, by means of a valved cylinder, termed a *sand-pump*.

As the drilling proceeds, the well is lined with *casing*, which is usually wrought-iron screwed artesian tubing, but in Russia, where the wells are of exceptionally large diameter, riveted iron casing is largely used. In many localities where there is a considerable thickness of superficial soft formation, the upper part of the bore-hole is lined with *drive pipe*, which is forced down, this operation being facilitated by placing a sharp-edged *shoe* on the lower end.

Within recent years the rotary system of drilling has been adopted to an increasing extent. In this system the drill is attached to a string of casing or tubing, suspended from a revolving table driven by a steam-engine, and is thus rapidly rotated. A stream of water containing clay in suspension is continuously pumped through the casing, the detritus being carried away in the issuing stream flowing through the annular space between the revolving casing and the borehole, whilst at the same time the clay suspended in the water is deposited on the surface of the boring, consolidating the formation and preventing the passage of the water into porous strata. The rotary system has been proved to be the most rapid and economical method of drilling oil-wells in strata to which it is suited, and recent improvements have rendered it more effective than it was formerly in hard strata, but in many instances it has been found necessary to supplement it with the percussion system, and combination rigs in which the two systems can be employed alternatively are now supplied.

It will be understood that the foregoing is merely a brief outline of the systems of drilling referred to. Fuller particulars will be found in larger works, such as *Petroleum*, 3rd ed., 1913 (Charles Griffin & Co., Ltd.).

As an example of what can be accomplished by the Canadian-Galician system of drilling, it may be mentioned that a well has recently been sunk in the Tustanowice field, in Galicia, to a depth of 1753 metres, or 5751 feet, the last string of casing having a diameter of 4 inches.

In Japan, in addition to the American cable system, two native methods of reaching the petroliferous strata are occasionally employed.

Where the depth required is small, or where the productive beds are thin, a hand-dug shaft 4 to 6 feet square is excavated, this being known as "Tebori."

There is also a method of hand-boring similar to that employed in Chinese brine-wells, known as "Kadzusabori."

A derrick 30 feet high is employed, and the place of the walking-beam is taken by a bamboo pole, the natural elasticity of which admits of vertical motion being readily imparted to the suspended drilling appliances. The combined drilling-cable and sand-line is made of split bamboo, jointed in short lengths. It is wound on a wooden wheel 12 to 18 feet in diameter, turned by three workmen. Progress is naturally slow, but the method is cheap, only five men being required; whilst for the American system it is necessary to have eight, in addition to steam power. For the "Tebori" only four men are employed.

DRILLING-ENGINES.

The steam-engines employed in drilling wells are as a general rule of the single-cylinder horizontal type, and are usually set on a solid wooden foundation. They are provided with feed-water heater, pump, fly-wheel, and pulley, and in most cases with a reversing-link motion.

In America additional rims are supplied for fitting on the fly-wheels when the load on the engine becomes greater as the depth of the well increases. The smaller engines are provided with one extra rim for this purpose,

the medium with two, and those of higher horse-power with three.

In Russia it is customary to use twin-cylinder horizontal steam-engines.

All drilling-engines should be of strong and simple construction, and their parts should be interchangeable.

The horse-power varies considerably, ranging from 12 to more than 60. For wells of moderate depth a 30 to 35 horse-power engine is generally considered sufficient.

BOILERS.

Many types of boilers are employed for steam-raising purposes in oil-fields. In the Baku field, batteries of boilers of the Cornish or Lancashire type are generally used for supplying steam to the engines at a number of drilling wells, and the steam mains are of considerable length. In Galicia the boiler employed in drilling operations is a portable one of the locomotive type, one or more being placed at a regulation distance from the well. Under-fired return-flue boilers are also used. In Rumania the practice is similar to that of Galicia.

In the eastern fields of the United States both portable and stationary locomotive-type boilers are employed, but in California it is customary to use an ordinary locomotive-type boiler, supported by means of stout timber or pieces of casing and provided with a brick setting round the lower part.

It occasionally happens that, on account of transport difficulties, boilers have to be made in sections, which can be bolted together on the ground, each section being of such weight that it can be carried by a mule or camel. Such boilers are not as satisfactory as ordinary boilers, and should only be used in cases of necessity. Figs. 19 to 22 indicate the types of boilers in common use.

Each nominal horse-power of boilers requires one cubic foot or $6\frac{1}{4}$ gallons of water per hour.

In calculating horse-power of tubular or flue boilers, it is usual to consider 15 square feet of heating surface as equivalent to one nominal horse-power.

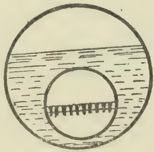


FIG. 19.—Cornish boiler.

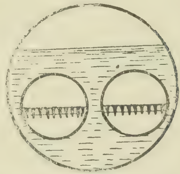


FIG. 20.—Lancashire boiler.

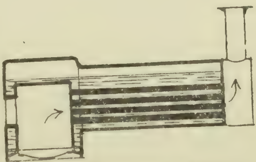


FIG. 21.—Locomotive boiler.

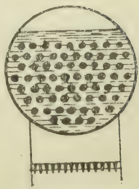


FIG. 22.—Under-fired return-flue boiler.

For cylindrical double-flued boilers, an approximate rule is :—

$$\frac{\text{Length} \times \text{diameter}}{6} = \text{nominal horse-power.}$$

For drilling operations steam-engines and boilers should be provided of ample size, allowing a margin over and above the actual power needed. An engine and boiler barely fitted to do the work required of them are a source of continual annoyance and delay.

DESCRIPTION OF THREADS USED ON DRILLING TOOLS.

The tools used in the percussive system of drilling are joined together by what are known as pins and boxes.

As a perfect joint is one of the most important factors in the efficiency of a "string" of tools, the greatest care is employed in the manufacture of such joints.

In the United States of America the joints are now practically standardised, and are all of the taper or conical form, the old straight joint having been practically discarded.

In specifying a joint, the diameters of the pin at the top and bottom, the number of threads to the inch, and their form—either "sharp" (V-shaped) or "flat"—and the size of the wrench-square below the collar or shoulder are given.

The usual height of the pin on a joint is 4 inches, and the taper is indicated by the difference of the diameters of the top and bottom of the pin.

Example.—$2\frac{1}{2} \times 3\frac{1}{2} \times 7$ flat, 4 inches square, represents a joint commonly used on a "string" of tools in drilling a 6-inch hole.

For all joints larger than 2 inches by 3 inches, 7 flat threads are usually employed, and on 2-inch by 3-inch joints and smaller sizes, 8 sharp threads. The 7 sharp threads are no longer in use.

The faces of the joints should be absolutely square and true, so that the box and pin when screwed together make a perfect joint.

CASING.

The casing inserted in wells in different oil-fields varies considerably as regards weight, the method of jointing, the number of threads, and the internal diameter.

Artesian casing is made of wrought iron or steel, and is either lap- or butt-welded (figs. 23 and 24). A special type known as Mannesmann (seamless) is also used in the Galician and Rumanian fields.

Riveted casing, commonly called by American drillers "stove-pipe," is employed in many instances, in the initial stage of drilling a well, to shut off gravel or any other formation met with which is likely to "cave."

In Russia stout riveted casing is mainly used in the lining of deep wells. It is made of iron plate of various

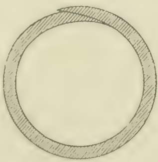


FIG. 23.—Lap-welded tube.

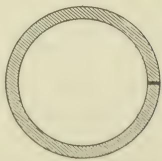


FIG. 24.—Butt-welded tube.

thicknesses, punched and rolled cold and then riveted. Such casing, which is made in comparatively short lengths, is either lap-welded or butt-welded and strapped, and each piece is provided with a collar, to which, when placed in the well, an additional length can be riveted cold at the well's mouth by means of a special instrument.

"Artesian" or "screwed" casing—generally termed "hermetic" pipe in Austria and Russia to distinguish it from "riveted" casing—is the only class of casing employed in petroleum-boring operations in the U.S.A., Mexico, and Austria, and is always lap-welded.

There are two varieties of screwed casing in general use, viz., "coupled" and "inserted joint." The former class is subdivided into "drive pipe" and "lap-welded

casing," both of which are provided with collars or sockets (couplings); the latter into "inserted cressed and swelled joint" and "flush joint" casing.

Drive pipe, as its name indicates, can be driven through soft formations, and for this purpose the threads on the pipe and in the couplings (collars) are not tapered, so that the ends of the pipe butt in the couplings and

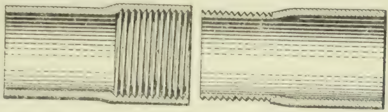


FIG. 25.—Swelled and cressed tubes.

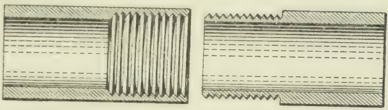


FIG. 26.—Tubes flush inside and outside.

the whole string thus forms a solid and rigid column. It is considerably heavier than ordinary casing, is made only in standard weights per foot, and always has 8 threads to the inch.

Lap-welded casing is a lighter class of coupled pipe, provided with tapered threads on pipe and couplings, with the object of obtaining a tight joint even after it has been repeatedly withdrawn and reset. Casing is made of various weights per foot according to require-

ments, and the number of threads to the inch are in proportion to the thickness of the pipe. Up to 5 inches, 14 threads are customary, and all sizes above 5 inches have $11\frac{1}{2}$ threads in the eastern and central parts of the U.S.A., but in California all sizes have 10 threads to the inch.

The couplings for drive pipe and casing are furnished with a sleeve or blank recess from $\frac{1}{2}$ inch to $\frac{5}{8}$ inch depth to facilitate screwing up.

All threads are right-hand.

The dimensions of drive-pipe and casing are always specified by giving the internal diameter of the pipe required, up to 3 inches; for larger sizes the external diameter, adding the letters O.D. (outside diameter), should be given, and in all cases the weight per foot must be added.

Extra heavy (X) and double extra heavy (XX) casing of a given diameter retains the outside diameter of the standard size of pipe of the given diameter, but the internal diameter becomes reduced in proportion to its strength, so that it can always be connected with standard fittings, such as casing heads and valves.

Inserted joint casing is chiefly used with the Galician-Canadian drilling system, and has the advantage that a larger number of "strings" can be inserted in a borehole than would be possible with "coupled" casing.

In ordering inserted joint casing, the internal diameter of the pipe required is usually given, also the weight per foot, the number of threads to the inch depending upon the thickness of the pipe ordered. In Austria it is understood that the ends of the pipe are to be swelled and cressed, and that a recess must be provided on the female joints.

Flush joint casing, which is only a lighter class of drive-pipe, is chiefly used in shallow water-wells, and very rarely in oil-wells.

WEIGHTS AND DIMENSIONS OF DIAMOND B. X. CASING USED IN THE OIL-FIELDS OF CALIFORNIA.

Nominal Inside Diameter. Inches.	Actual Outside Diameter. Inches.	Nominal Weight per foot in lbs.	Tested to lbs. per sq. in.
$5\frac{5}{8}$	6	20	..
$6\frac{1}{4}$	$6\frac{5}{8}$	20	..
$6\frac{5}{8}$	7	20	1,200
$8\frac{1}{4}$	$8\frac{5}{8}$	28	1,000
$9\frac{5}{8}$	10	33	..
10	$10\frac{3}{4}$	40	800
$11\frac{5}{8}$	12	40	..
$12\frac{1}{2}$	13	40	..
$13\frac{1}{2}$	14	50	..
Diamond B. X. Drive-Pipe.			
$4\frac{1}{2}$	5	15	..

The above casing is screwed 10 threads to the inch. All weights are subject to a variation of 5 per cent.

RULES FOR ASCERTAINING WEIGHT OF PIPES.

D = External diameter of pipe in inches.
d = Internal ,, ,,
W = Weight of a lineal foot of pipe in lbs.
$W = K(D^2 - d^2)$ or $K(D+d)(D-d)$. K being constant for each material, viz. 2·45 for cast iron, 2·64 for wrought iron, 2·82 for brass, 3·03 for copper, 3·86 for lead.

Example.—Required the weight per foot of a 3-inch standard boiler tube. 3-inch external diameter squared $=9$; 2·782-inch internal diameter squared $=7{\cdot}739524$. $9-7{\cdot}739524=1{\cdot}260476\times2{\cdot}64=3{\cdot}32$ lbs. per foot.

Second example.—External + internal diameter 5·782. Difference 0·218. $5{\cdot}782\times0{\cdot}218=1{\cdot}260476$, which $\times\,2{\cdot}64$ for wrought iron $=3{\cdot}32765664$ lbs. per foot.

DRILLING-CABLES AND BULL-ROPES, ETC., USED IN THE CABLE SYSTEM OF DRILLING.

In England, rope is measured by its circumference; but in the United States of America, manila drilling-cables

FIG. 27.—Hawser laid manila rope.

FIG. 28.—Plain laid manila rope.

and other ropes used in drilling operations are measured by their diameter. As a rule, ropes used for drilling, sand-lines, and hoisting purposes generally, are hawser laid, and bull- and calf-ropes plain laid. See figs. 27 and 28.

Drilling-cables can be obtained up to 4000 feet in length without a splice. Manila ropes are sold by weight.

APPROXIMATE WEIGHTS AND DIAMETERS OF MANILA DRILLING-CABLE.

Diameter. Inches.	Weight per Foot. Lbs.
1	$\frac{2}{5}$
$1\frac{1}{8}$	$\frac{1}{2}$
$1\frac{1}{4}$	$\frac{3}{5}$
$1\frac{1}{2}$	$\frac{3}{4}$
$1\frac{5}{8}$	1
$1\frac{3}{4}$	$1\frac{1}{5}$
$1\frac{7}{8}$	$1\frac{1}{3}$
2	$1\frac{2}{5}$
$2\frac{1}{8}$	$1\frac{2}{3}$
$2\frac{1}{4}$	$1\frac{9}{10}$
$2\frac{1}{2}$	$2\frac{1}{8}$

APPROXIMATE WEIGHTS AND DIAMETERS OF MANILA BULL-ROPE.

Diameter. Inches.	Weight per Foot. Lbs.
2	$1\frac{1}{3}$
$2\frac{1}{8}$	$1\frac{1}{2}$
$2\frac{1}{4}$	$1\frac{5}{8}$
$2\frac{1}{2}$	$2\frac{1}{8}$
$2\frac{3}{4}$	$2\frac{1}{2}$
3	3

APPROXIMATE WEIGHTS AND DIAMETERS OF MANILA SAND-PUMP LINE.

Diameter. Inches.	Weight per Foot. Lbs.
$\frac{1}{2}$	$\frac{1}{8}$
$\frac{5}{8}$	$\frac{1}{5}$
$\frac{3}{4}$	$\frac{1}{4}$
$\frac{7}{8}$	$\frac{1}{3}$
1	$\frac{2}{5}$
$1\frac{1}{8}$	$\frac{1}{2}$
$1\frac{1}{4}$	$\frac{3}{5}$

To find the Breaking Weight of Round Ropes.

Hemp $\frac{(\text{Circum. ins.})^2}{5}$ = breaking weight in tons.

Iron wire (Circum. ins.)$^2 \times 1{\cdot}5$ = breaking weight in tons.
Steel wire (Circum. ins.)$^2 \times 2{\cdot}5$ = " " "

To find the Weight of Hemp Ropes.

(Circum. ins.)$^2 \times {\cdot}26$ = weight in lbs. per fathom.

Newbigging.

WIRE-ROPES.

Wire-ropes are extensively used in drilling operations. Those used for drilling are made left-hand lay, and those employed for bailing, handling casing, or sand-pumping are made right-hand lay. See figs. 29 and 30.

FIG. 29.—Left-hand lay wire-rope.

FIG. 30.—Right-hand lay wire-rope.

BABBITT'S METAL.

This alloy, which is usually composed of 50 parts of tin, 4 parts of antimony, and 1 part of copper, is extensively used as an anti-friction metal for bearings.

WATER.

The question of water supply in connection with the production of oil or gas is a most important one. An adequate supply, not only for use in boilers and in bore-holes but also for domestic consumption, must be provided. Generally this presents little difficulty, but sometimes involves the expense of a pipe-line from the nearest source of supply. Where water is scarce,

internal-combustion engines can be used for drilling, pumping, and workshop purposes. When oil properties are being developed in the vicinity of the sea, and where no fresh-water is obtainable, as, for instance, in the Island of Tcheleken, a supply of potable water and of water for steam-raising purposes, etc., can be obtained by the distillation of sea-water. The requisite plant is not costly.

The exclusion of water from the oil-bearing strata is equally essential. In most oil-fields water is encountered in drilling for oil either above or below the oil-bearing formation, or the water stratum may be met with in close proximity to and between oil-bearing strata. Years ago very little attention was paid to the influx of water into a producing well, and, as a rule, on a well being abandoned no efforts were made to plug the water off and prevent the flooding of the oil-sands in the immediate vicinity of the abandoned borehole. One of the writers, about 25 years ago, while in charge of an oil property, "brought in" a well giving a production of a little more than 90 barrels per diem, the largest and best producer in the district in which it was situated. Unfortunately, the oil was accompanied by water. Owing to want of tankage, instructions were received to shut the wells down. In spite of protests that if the particular well referred to was "shut down" it would be ruined, and that it would be better to pump the oil into a sump-hole and burn it, the directors of the company insisted upon the well being closed. The result was that on recommencing pumping the well gave nothing but "roily oil" * for more than a month, and in spite of all efforts the production only reached 15 barrels a day. It has now become recognised that it is essential to the preservation of an oil-field that water should be "shut off" both in producing and in abandoned wells, and in several countries laws have been introduced to render this compulsory.

* See p. 244.

Unfortunately, however, except in the case of abandoned wells, it cannot always be effectively carried out, and a certain amount of water must in many instances necessarily be produced with the oil. In cases where the pumps can handle the water this is, as a rule, not of very great consequence. When the ordinary pumps are inadequate to cope with the water, it can be raised, together with the oil, by means of compressed air, and if the influx of water can be dealt with no flooding of the surrounding oil strata takes place.

In either case, however, the oil may become emulsified, and in some instances to such a degree that the separation of the oil from the water is a difficult and expensive matter. In the more or less complete emulsion of the oil with water, in which the water will not separate by subsidence (free water with the oil can easily be separated), various methods are used. One of the most recent is an electrical treatment,* which has been successfully employed in dealing with refractory emulsified crude oil in California.

The sinking of new boreholes in the neighbourhood of abandoned wells which have produced oil, but in which the water has not been shut off, has frequently been attended with most unsatisfactory results, on account of the oil-bearing formation in the vicinity of the abandoned well having become waterlogged. The authors have on several occasions met with instances of this kind, in which, if careful consideration had been given to the circumstances, fruitless expense and disappointment would have been avoided.

As an illustration of the injury which may result from the admission of water into either oil- or gas-wells, it may be mentioned that for the purpose of closing a "wild" gas-well in the Caddo Field, Louisiana, a new well was sunk near the "wild" well, and through the former water

* For a description of this process see *Petroleum* (Charles Griffin & Co., Ltd.), 3rd ed., vol. i. p. 318.

was forced, with the result that the gas was "drowned out" in the first well.

The salient points in respect of water in the developing of an oil property may be summarised as follows :—

(1) In order to prevent delays a sufficient quantity of water must be available for carrying on the work all the year round.
(2) Every precaution should be taken to ensure that any water met with is properly "shut off."
(3) Abandoned wells should be effectively plugged.
(4) Wells should not be located in proximity to abandoned wells in regard to which it is known that water has not been effectively shut off, or there is a doubt as to whether it has been.

PRESSURE OF WATER IN WELLS.

Insufficient attention is generally paid to the pressure exerted by a column of water standing in a borehole, which may nevertheless produce very considerable effects.

In a well full or partly full of water there is a pressure on the bottom of the well proportionate to the height of the column of liquid, but the important point to be remembered in drilling operations is that this pressure is the same in all directions.

The casing of boreholes may therefore be subjected to very considerable strain, even in territory in which there are no caving strata (the effect of which is comparable to that of a true fluid), if the annular space outside the casing and the cylindrical space inside are not both full or both empty of water. If the liquid stands to an equal depth on both sides the pressure is equal, and no strain is set up.

The upward pressure of a column of water will also affect the power of the blow delivered by the drilling tools, their weight being decreased in proportion to the depth of water in which they are working.

The pressure depends only on the height of the column of water and not upon the diameter of the well, and the force exerted at different depths is given in the table on p. 331.

DRILLING LOGS.

Messrs Bergheim and MacGarvey have kindly allowed the authors to reproduce the drilling log given on the next page.

By the use of this log a profile of a borehole is clearly shown with regard to its size and the strata perforated, together with the dimensions and position of each string of casing. All details requisite in forming an opinion of the well can be inserted in this form. The advantages claimed are :—

(1) Employer and driller can have before them a working plan, as it were, of the progress of the bore at any and every stage of the work.
(2) After completion of it, copies can be taken without trouble or loss of time.
(3) Greater certainty is assured in regard to the position of casing.
(4) Where bores are situated in one line, the formation of a territory is easily followed by placing one sketch by the side of another.

Instructions for Use.

The form on one side, when filled in, will represent the profile of a bore in respect to its size and formation, and on the other, the dimensions and lengths of casing used in the borehole. Millimetre (horizontal) lines, each representing a metre, denote the progress downward, perpendicular lines (not kept to any scale) the dimensions of bits and casing. The amount of caving, reaming, under-reaming, shutting off of water, and position of pump in hole, for each of which distinguishing signs are provided, as shown in the key, can be clearly indicated.

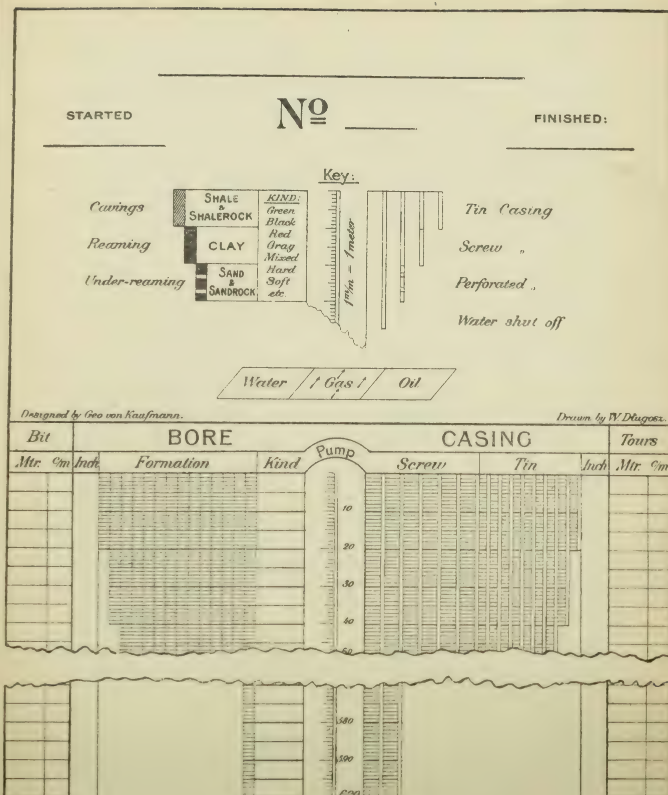


FIG. 31.—Example of drilling log.

In order to simplify the log only three kinds of strata are taken into account, viz. :—

1. Shale—blue.
2. Clay—red.
3. Rock—yellow.

The precise colour of these strata can further be specified by writing them in across these ground colours in the column reserved for the purpose, as illustrated in the key.

When water, gas, or oil is met with in one of these strata, it is only necessary to cover the ground colour with dots of colour prescribed in the key.

While the bore is in course of progress, the strata met with are filled in day by day by means of coloured pencils ; the size of casing, however, and quantity put in, should be pencilled in with black lead, so that the lines can be erased with a piece of indiarubber whenever a particular string of casing is withdrawn.

After completion of the bore, this working plan, which now represents the exact state of the bore, can be copied and filed for reference, the whole forming a complete record of the well.

The following is a form of log in use in the Californian oil-fields :—

DAILY DRILLING REPORT.

Well No.......... at .... Date...........19..

For 24 hours ending 12 o'clock noon.

Hours run...... Feet drilled...... Total depth ....
Time lost...... Cause of stoppage..................
....
Description of material drilled through...............
....
....
No. of feet of......inch casing set........

Remarks :—

....

....

....

....

Names of drillers. Names of toolies.

....

....

..............................Superintendent.

TORPEDOING WELLS.

The torpedoing or shooting of wells is extensively carried out in many oil-fields of the United States. This operation was invented by Col. Roberts and patented by him in 1862. It was not, however, until 1865 and 1866 that his invention was tried with favourable results. Since that time the shooting of wells with nitro-glycerine has become general, and the original 4 to 6 quarts of the explosive material used has been gradually increased until now it is customary in certain districts to use as much as 220 quarts, the quantity, however, depending upon the nature of the strata in which the oil is found. More explosive is required where the producing stratum is hard and of close texture than where it is coarse-grained and friable.

The method of procedure is as follows :—The nitro-glycerine is poured into tin cylinders or "shells," about 5 inches in diameter, and a little over 5 feet in length, each containing about 20 quarts. These shells are conical at the bottom and slightly concave at the top, so that when lowered consecutively into a well they fit more or less closely together. As each shell touches bottom the lowering line is released by a mechanical device and drawn up. The last shell is fitted with a waterproof percussion-cap connected with a small electric battery at the surface. When the shells are all in position it is customary to remove the casing to avoid risk of collapse or breakage.

In from half a minute to a minute after the charge is

exploded, a slight earth-tremor is felt in the neighbourhood of the well, accompanied by a muffled report, following which a roaring sound is heard, and a column of oil and water mingled with fragments of rock and tin-plate begins to issue from the borehole. The flow usually subsides in a short time, when the casing is reset, and, after being cleaned out, the well is tubed and connected with tank-storage.

DIAMETER AND APPROXIMATE LENGTH OF TWENTY-QUART SHELLS.

Diameter in Inches.	Number of Inches to Quart.	Length. Feet.	Length. Inches.
2	$18\frac{3}{4}$	30	$7\frac{5}{8}$
$2\frac{1}{4}$	$14\frac{1}{2}$	24	$2\frac{1}{2}$
$2\frac{1}{2}$	$11\frac{3}{4}$	19	$7\frac{1}{4}$
$2\frac{3}{4}$	$9\frac{3}{4}$	16	$2\frac{1}{2}$
3	$8\frac{1}{2}$	13	$7\frac{3}{8}$
$3\frac{1}{4}$	7	11	$7\frac{1}{4}$
$3\frac{1}{2}$	6	10	0
$3\frac{3}{4}$	$5\frac{1}{4}$	8	$8\frac{5}{8}$
4	$4\frac{5}{8}$	7	$7\frac{7}{8}$
$4\frac{1}{4}$	$4\frac{1}{8}$	6	$9\frac{3}{8}$
$4\frac{1}{2}$	$3\frac{5}{8}$	6	$0\frac{5}{8}$
$4\frac{3}{4}$	$3\frac{1}{4}$	5	$5\frac{1}{8}$
5	3	5	0
$5\frac{1}{4}$	$2\frac{2}{5}$	4	$4\frac{1}{2}$
$5\frac{1}{2}$	..	4	1
$5\frac{3}{4}$	..	3	9
6	..	3	4
$6\frac{1}{4}$	..	3	$1\frac{1}{2}$
$6\frac{1}{2}$	..	2	11
$6\frac{3}{4}$	..	2	$8\frac{1}{2}$
7	..	2	6

CEMENTING WELLS.

The cementing of boreholes for the purpose of holding back or shutting off water has been satisfactorily accomplished in many oil-fields. One of the most successful methods is that practised in the Californian oil-fields, and is as follows :—For the purpose of illustration the method of employing casing and cement in combination will be described. The casing with which it is desired to shut off the water must admit of being moved quite freely in the borehole, so that it may be raised or lowered the full length of a "stand," that is to say, three joints. A disc "wall-packer," or any other suitable packer, is then lowered on tubing, usually two or three inches in diameter. The packer is "tripped" and set in the bottom joint of the casing, and the tubing is connected by means of a flexible hose or a swing-jointed pipe to a powerful steam-pump similar to those used for hydraulic rotary drilling; water is then pumped down the borehole through the tubing, and in this manner a circulation of water is established up through the annular space outside the casing which it is desired to cement and the wall of the borehole, the return water flowing freely from the mouth of the borehole. It is necessary to move the casing and tubing together during the operation, and provision must be made for handling them in this manner, The casing having been raised off its seat, and a free circulation of water maintained, the cement is then mixed, and this is usually done in large shallow boxes or troughs. The cement is shot directly from the bags or barrels into the water, and is kept in a state of continuous agitation by means of hoes or mortar rakes. A sufficient number of men must be kept constantly at work stirring the cement to keep it in a liquid state until the whole mass has "ripened" and is in a fit state to be taken by the pump. The suction of the pump is now transferred

from the water-tank to the cement box, and the cement, in a liquid state, is pumped down the borehole through the tubing, and is forced up into the space between the outside of the casing and the wall of the borehole, the packer preventing its rising inside the casing. When enough cement has been pumped in to fill this space to a sufficient height, dependent on the nature of the strata, the suction pipe of the pump is again transferred to the water-tank and water is pumped down the tubing in order to clear it of cement. The casing and the tubing are then lowered to a seat, when the packer is "struck" and withdrawn, and the well is allowed to stand until the cement has become hard. The time required for this depends upon the nature of the cement used and the temperature of the borehole.

The success of the method is dependent upon the continuity of the work, as any stoppage or breakdown during the pumping-in of the cement is liable to prove disastrous, especially with a well having a high temperature, when the cement sets very rapidly if the flow is arrested. It frequently happens that the pressure while pumping the cement rises to 500 lbs. per square inch, and a pump capable of working at such a pressure must be provided, together with an adequate supply of water. In the experience of Mr William Sutton, who has furnished the authors with these particulars, the above method has been successfully carried out in many new boreholes, and, with certain modifications, in old wells which had been producing for a considerable time but which had become flooded with water gaining access to the borehole either through fissures in the strata or through the collapse or splitting of the casing. In the latter circumstances it is often necessary to perforate or split the casing in order to get effective circulation, and washing with a current of water may have to be carried on for a considerable period.

METHODS OF RAISING OIL.

When petroleum has been met with in drilling, the most advantageous way of raising it to the surface has next to be considered. If the pressure of the gas associated with the oil is sufficient to cause the well to flow, the problem will be rendered simple or difficult according to the force manifested. A gentle flow can easily be directed into storage-tanks, or shut off (**capped**) until these are prepared; a powerful "gusher," however, may prove very difficult to bring under control. In either case no mechanical device is needed to bring the oil to the surface.

For raising oil in non-flowing wells, various means have been adopted. The simplest, and at the same time the slowest, method is that of **bailing**, which does not differ essentially from the lowering of a bucket into an old-fashioned water-well. This method is often resorted to in the preliminary testing of a well, and it is the usual means employed in the Baku fields, where very large quantities of sand are mixed with the oil and prevent the use of ordinary pumps. The form of bailer used is shown in fig. 32. The valve is opened by contact with a sliding board pushed under the apparatus, the oil being allowed to flow into a wooden tank, where the sand settles out.

Ordinarily, however, if the trial bailing shows the presence of sufficient oil, the well is **pumped** by means of a working barrel and a valved sucker, of the form shown in fig. 33. The sucker is connected by a string of sucker rods with an oscillating beam, several wells (sometimes as many as 250, if shallow) being pumped from one central power-station.

Yet another method, known as the "**airlift**," has been invented in America, and is now widely used. Compressed air is driven down the annular space between two concentric tubes, causing the oil to come to the surface through the centre one.

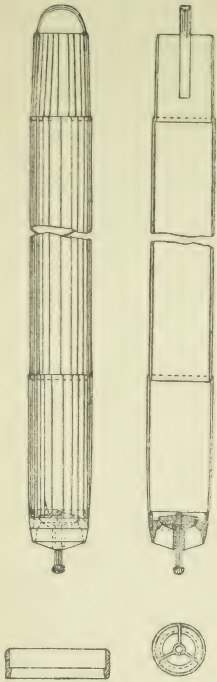


FIG. 32.—Bailer.

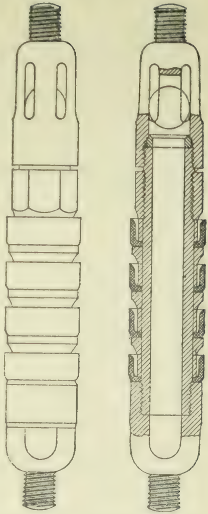


FIG. 33.—Valved sucker.

Another form of pumping plant, known as the Mascot power, which is extensively used, is constructed in the following manner :—A bearing carrying a vertical shaft about 4 inches in diameter is set on heavy wooden mud sills, which are filled in with concrete, and upon this shaft is keyed a laminated-wood band-wheel about 15 feet in diameter, having the ordinary cast-iron flange centering-irons. Above this are set one or two eccentrics and straps according to the number of wells to be pumped, to the periphery of which are attached tubular rods, which pass over suitable guides, and are connected to the jerker lines running to each well. Above the eccentrics there is an upper steadying bearing for the main shaft, supported by tie-rods or guys, fitted with turnbuckle tighteners, attached to the mud sills.

The driving belt drives direct from the pulley on the engine shaft to the band-wheel, there being a half twist thrown in the belt to convert the horizontal into a vertical motion. The belt is kept tight by means of a jockey-pulley centred in a frame, which is adjustable for lateral movement by means of a rack and pinion on an inclined plane or a screw device. The belts generally employed are 10 inches in width and are made of 6-ply canvas, the average length being 130 feet.

These powers are generally driven by a gas-engine of 25 to 35 h.p., having single water-jacketed cylinders with tube ignition. Two fly-wheels are mounted on the crank shaft, and this shaft is provided with an extension at one end working in a tail-bearing. On this extension is carried a self-contained friction-clutch pulley.

PIPE AND TUBING.

There are four classes of pipe, other than casing, in use in the petroleum industry and oil-fields :—

1. Merchant pipe, either black or galvanized.
2. Tubing.

3. Line pipe.
4. Special rotary-drill pipe.

1. Merchant pipe, which is used for water, steam, and short oil- and gas-lines, is manufactured in three weights per foot, viz. light, medium, and heavy, from $\frac{1}{8}$-inch to 15 inches diameter. The light quality is butt-welded in the U.S.A. up to $1\frac{1}{2}$ inch, and in the U.K. up to 2 inches. All larger sizes and heavier qualities are lap-welded.

   The threads on this class of pipe are tapered and the couplings are without sleeves (not recessed).

   The standards of thread in the U.S.A. and the U.K. differ considerably. In the U.S.A. there are 27 to $11\frac{1}{2}$ threads to the inch up to 2 inches diameter, and all larger sizes have 8 threads to the inch. In the U.K., since July 1909, there are 28 to 14 threads up to $\frac{7}{8}$-inch diameter, and in respect of all larger sizes 11 threads to the inch.

2. Tubing is universally used in pumping oil-wells, for light fishing jobs, and for rotary-drilling in light ground. It is made in sizes from 1 inch to 6 inches diameter, is always lap-welded and carefully plugged and reamed inside. The threads are tapered, and the couplings, which are from 25 to 40 per cent. longer than those of merchant pipe, are provided with sleeves (recessed).

3. Line pipe is a special pipe employed for long-distance water, gas, and oil pipe-lines. It is lap-welded and manufactured in sizes from 2 inches to 12 inches diameter. The weights per foot and the threads per inch are standardised in the U S.A.—2-inch pipe $11\frac{1}{2}$ threads, all larger sizes 8 threads. All threads are tapered and the couplings recessed. Each length is tested for gas-line purposes up to 1200 lbs. per square inch, for oil pipe-lines to 1800 lbs. and 2000 lbs.

4. Special rotary-drill pipe is only used for rotary-drilling in heavy ground and deep wells. It is very much heavier than the corresponding sizes of tubing and line-pipe, and has longer and heavier couplings (sockets). It is manufactured only in sizes from $2\frac{1}{2}$ inches to 6 inches diameter, all sizes with 8 tapered threads to the inch.

A $2\frac{1}{2}$-inch, 4-inch, and 6-inch special rotary pipe with upset ends is also on the market.

Unless specially ordered, all the above classes of pipe are delivered by the manufacturers in random lengths from 16 to 24 feet, threaded on both ends, and with one socket on each pipe.

All specified weights are subject to a variation of 5 per cent. above or below standard in the U.S.A.

BRITISH STANDARD PIPE-THREADS FOR IRON AND STEEL PIPES AND TUBES, AUTHORISED BY THE BRITISH ENGINEERING STANDARDS COMMITTEE. ADOPTED JULY 1, 1909.

SCHEDULE OF SIZES.

Nominal Bore of Tube.	Approximate outside Diameter of Black Tube.	Gauge Diameter, Top of Thread.	Depth of Thread.	Number of Threads per Inch.
Inches.	Inches.	Inches.	Inches.	
$\frac{1}{8}$	$\frac{13}{32}$	·383	·0230	28
$\frac{1}{4}$	$\frac{17}{32}$	·518	·0335	19
$\frac{3}{8}$	$\frac{11}{16}$	·656	·0335	19
$\frac{1}{2}$	$\frac{27}{32}$	·825	·0455	14
$\frac{5}{8}$	$\frac{15}{16}$	·902	·0455	14
$\frac{3}{4}$	$1\frac{1}{16}$	1·041	·0455	14
$\frac{7}{8}$	$1\frac{7}{32}$	1·189	·0455	14
1	$1\frac{11}{32}$	1·309	·0580	11
$1\frac{1}{4}$	$1\frac{11}{16}$	1·650	·0580	11
$1\frac{1}{2}$	$1\frac{29}{32}$	1·882	·0580	11
$1\frac{3}{4}$	$2\frac{5}{32}$	2·116	·0580	11
2	$2\frac{3}{8}$	2·347	·0580	11
$2\frac{1}{4}$	$2\frac{5}{8}$	2·587	·0580	11
$2\frac{1}{2}$	3	2·960	·0580	11
$2\frac{3}{4}$	$3\frac{1}{4}$	3·210	·0580	11
3	$3\frac{1}{2}$	3·460	·0580	11
$3\frac{1}{4}$	$3\frac{3}{4}$	3·700	·0580	11
$3\frac{1}{2}$	4	3·950	·0580	11
$3\frac{3}{4}$	$4\frac{1}{4}$	4·200	·0580	11
4	$4\frac{1}{2}$	4·450	·0580	11
$4\frac{1}{2}$	5	4·950	·0580	11
5	$5\frac{1}{2}$	5·450	·0580	11
$5\frac{1}{2}$	6	5·950	·0580	11
6	$6\frac{1}{2}$	6·450	·0580	11

Gauge diameter is the full diameter of the standard male screw gauge, which the coupler, to be used with a pipe of that size, is required to fit; it may therefore, for all practical purposes, be regarded as the full diameter of the coupler screw.

Threads are of Whitworth form; the angle between the slopes measured in the axial plane is 55°; the threads are rounded equally at crests and roots, leaving a depth of thread approximately equal to 0·64 times the pitch.

SCHEDULE OF STANDARDS IN THE U.S.A. FOR WROUGHT MERCHANT PIPE.

Nominal Inside Diameter.	Outside Diameter.	Threads per Inch.	Weight per Foot.		
			Ordinary.	Extra Strong (X).	Double Extra Strong (XX).
Inches.	Inches.		Lbs.	Lbs.	Lbs.
1/8	·405	27	·24	·29	..
1/4	·540	18	·42	·54	..
3/8	·675	18	·56	·74	..
1/2	·840	14	·84	1·09	1·70
3/4	1·050	14	1·12	1·39	2·44
1	1·315	11½	1·67	2·17	3·65
1¼	1·660	11½	2·24	3·00	5·20
1½	1·900	11½	2·68	3·63	6·40
2	2·375	11½	3·61	5·02	9·02
2½	2·875	8	5·74	7·67	13·68
3	3·500	8	7·54	10·25	18·56
3½	4·000	8	9·00	12·47	22·75
4	4·500	8	10·66	14·97	27·48
4½	5·000	8	12·49	18·22	32·53
5	5·563	8	14·50	20·54	38·12
6	6·625	8	18·76	28·58	53·11

All weights are subject to a variation of 5 per cent. above or below standard.

Ordinary merchant pipe is delivered with threads cut on both ends and one socket on each length.

Extra strong and double extra strong (X and XX) pipe is supplied with plain (unthreaded) ends, and without sockets, in random lengths from 12 to 22 feet; an extra charge is made for pipe fitted with threads and sockets.

PLUGGING OF ABANDONED WELLS.

It is now customary in most countries when a well has been abandoned to "plug it," in order to prevent the influx of water into the oil-bearing formation. In the early days of the petroleum industry no attention was paid to this, and undoubtedly many fields became partially water-logged in consequence. Of some countries, at the present day even, it may be said that sufficient attention is still not paid to this important matter.

In the United States, where practically very few laws and regulations are imposed in connection with the petroleum industry, it has been recognised that the plugging of abandoned wells is essential. As an illustration, the requirements of the State of Illinois in this respect are set forth below:—

STATE OF ILLINOIS, } SS.
Lawrence County. }

.... and ...., being first duly sworn on their oaths, say, that on the.......... day of.................A.D. 19....,.................. plugged a certain oil- or gas-well, owned by........... .... and located on the following described real estate, to wit:...........................
....
....
.........in the County of.................. State of Illinois.

That they, affiants, were both present during the plugging of said well and saw the same plugged, that said well was plugged by first being solidly filled from the bottom thereof to a point at least twenty-five feet above the gas- or oil-bearing rock, with.................., immediately on top of which filling was seated a dry wood plug, not less that two feet in length, having a diameter of not less than one-fourth of an inch less than the inside diameter of the casing in such well. Above such wood plug such well was solidly filled for at least twenty-five feet with the above mentioned filling material, immediately above which was seated another wood plug of the same kind and size as above described, and such well was again solidly filled for at least twenty-five feet above such last mentioned plug with such filling material. After the casing had been drawn from such well there was immediately seated at the point where such casing was seated a cast-iron ball (or tampered wood plug at least two feet in length), the diameter of such ball (or the top of which plug) was greater than that of the hole below the point where such casing was seated, and above such ball (or plug) such well was solidly filled to the top of well with the aforesaid filling material.

....

....

Subscribed and sworn to before me by the said........ .... this .... day of .... 19......

....

Notary Public.

EXTRACT FROM "PROPOSED REGULATIONS FOR THE DRILLING OF GAS- AND OIL-WELLS, WITH COMMENTS THEREON," BY O. P. HOOD AND A. G. HEGGEM, BUREAU OF MINES, TECHNICAL PAPER 53, PETROLEUM TECHNOLOGY 12.*

ARTICLE IV.

Abandonment of Well.

Notice.

Sec. 1. The well-operator, when he purposes to abandon any well, shall send a written notice of his intention to the chief well-inspector, and the work of plugging the hole or pulling the casing shall not proceed until the well-inspector shall be present to see that said plugging is done as prescribed by these regulations, except as hereinafter provided.

Procedure in absence of inspector.

Sec. 2. In case the well-inspector fails to be present within three days from receipt of notice, then the work may proceed, provided that two men who have had at least three years' experience in the plugging of wells are present and make affidavit in duplicate that the work was done in accordance with the provisions of these regulations, said affidavits to be filed with the chief well-inspector and put on record in his office.

Copy of license.

Sec. 3. With the notice of abandonment the well-operator shall send to

* Department of the Interior, Government Printing Office, Washington, 1913.

the chief well-inspector a legally certified copy of the license to drill, provided the well was drilled under the provisions of these regulations.

Locating old wells.

Sec. 4. If the well was drilled prior to the passage of these regulations, the well-operator shall send to the chief well-inspector with the notice of abandonment a description and plat, as described and platted in applications for license to drill, showing the location of the well.

Method of plugging.

Sec. 5. Every well, upon abandonment, must be plugged and filled solidly and tightly from the bottom to the top as follows :—

The hole must be filled with rock sediment, sand, clay, or other suitable material from the bottom of the well to a hard and firm stratum below the last string of casing set in above the producing oil- or gas-sands. If a well-inspector shall declare that it is impracticable to fill the cavity in the lowest producing sand, then he shall permit the well-operator to place plugs at the top of the lowest producing sand and to fill as hereafter specified.

In the firm, hard stratum three seasoned wood plugs of a diameter equal to the diameter of the hole, and each of a length of at least three (3) feet, shall be driven into place. Above the third plug ten (10) feet of clay must be placed and thoroughly tamped down so as to prevent the passage of oil, gas, or water.

Immediately below the seat of each

and every string of casing there shall be driven a seasoned wood plug as described, and all spaces between wood plugs shall be filled solidly and tightly with rock sediment, clay, sand, or other suitable material as the casing is withdrawn length by length. All plugs shall be driven in place with proper drilling tools.

In the case of a well in which the outside casing has been cemented as herebefore prescribed, said outer casing may be cut off at a point not less than fifty (50) feet above the coal-bed and removed, but in any event the hole shall be filled to the surface.

The locations of the plugs as herein prescribed are designated with reference to the relative positions of the workable coal-beds, and of the gas- and oil-sands, for the purpose of preventing the passage of oil or gas into the workable coal-beds, and of water into the oil- and gas-sands; and if any well presents a variation in such relative positions of the said strata, such additional wood plugs as the well-inspector may deem necessary shall be driven into place by the well operator.

Report of plugging.

Sec. 6. When the work of plugging and filling from bottom to top shall have been completed, the well-operator, or his authorised agent, shall make a report in duplicate to the chief well-inspector, on forms to be furnished by the well-inspector, showing the date of completion of the well, the depths

to the coal-beds, the names of and the depths to all productive oil or gas measures, the total depth of the well, and the location and kind of all plugs and filling used, and the method followed in placing the same.

Sec. 7. If the well-inspector has been present during the performance of the work mentioned in Section 6 of this article, he also shall sign the report to the chief well-inspector.

Sec. 8. If the well-inspector has not been present, the report mentioned in Section 6 of this article shall be executed by two men employed on the work, as provided for in these regulations.

Protection of casing by coal operator.

Sec. 9. When the coal is removed from around a well casing or liner, the coal-operator shall protect said casing or liner from corrosion and mechanical injury by a wall of material suitable to retain two (2) inches of cement mortar between the said wall and the said casing or liner; this protection shall extend from two (2) feet below the mine floor to the roof of the mine, except in the case of an abandoned well that has been plugged and filled as prescribed in these regulations.

Extract from "Proposed Regulations for the Drilling of Gas- and Oil-Wells," with Comments thereon, by O. P. Hood and A. G. Heggem, Bureau of Mines, Technical Paper 53, Petroleum Technology 12.

Method of Plugging.*

Two principles are involved in the method of plugging —first, the passage of oil, gas, or water from one stratum to another must be prevented; second, any spaces or pockets that may contain gas under pressure and that might find sudden relief should be eliminated.

Methods of plugging shown in fig. 34.

Fig. 34 shows six methods of plugging wells.

From left to right in the figure the methods indicate increase in effectiveness.

Plugging shown in I.

The plugging shown in I. (fig. 34) is typical of that frequently used under existing laws.

Advantages: shuts out water from gas-sand.

Disadvantages: allows the free intermingling of waters from different strata, causing the pollution of waters, springs, and wells.

The hole cannot be maintained open to atmosphere. The top will cave and plug the hole above the coal-bed.

Allows pocket for storage of gas under pressure.

Gas may escape into the hole and remain a menace to mine operations.

This plug cannot be set against a heavy gas (or rock) pressure.

Plugging shown in II.

The type of plugging represented in II. (fig. 34) offers the following advantages and disadvantages:—

* Art. IV. Sec. 5.

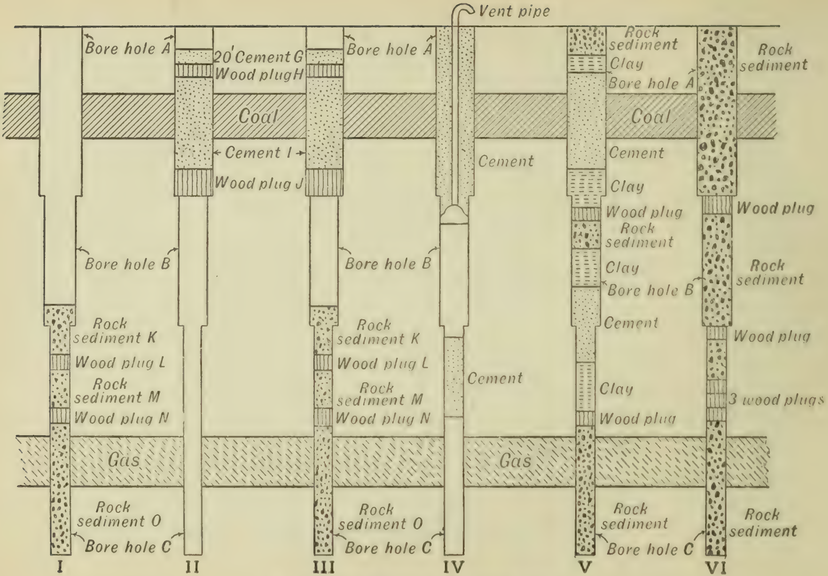


FIG. 34.—Six methods of plugging wells.

Advantages: shuts out water from coal-beds. Shuts out gas from coal-beds.

Disadvantages: allows pocket for storage of gas under pressure. Allows gas to enter formation below coal-bed. Allows the free intermingling of waters from different strata. Cannot be used in case of heavy gas pressure.

Plugging shown in III.

The type of plugging shown in III. (fig. 34) represents a combination of the types shown in I. and II.

Advantages: shuts out water from coal-bed. Shuts out gas from coal-bed. Shuts out water from gas-sand.

Disadvantages: allows pocket for storage of gas under pressure. Allows the free intermingling of waters from different strata. Gas may pass lower plug and escape into the formation below the coal-bed. This plug cannot be set against a heavy gas pressure.

Plugging shown in IV.

The type of plugging shown in IV. (fig. 34) provides for a vent in that part of the plug that passes through the coal.

Advantages: shuts out water from coal-bed. Shuts out gas from coal-bed. Shuts out water from gas-sand.

Disadvantages: allows pocket for storage of gas under pressure. Allows intermingling of waters from different strata. Allows intermingling of oil and gas from different strata. Vent-pipe may easily be broken or corroded if cement is broken, especially through inaccessible mine opening. Plugging against gas pressure difficult. Safety absolutely dependent on integrity of vent-pipe.

Plugging shown in V.

The method of plugging shown in V. (fig. 34) comprises a composite clay and cement plug.

Advantages: allows no pocket for storage of gas

under pressure. Shuts out gas, oil, and water from the coal-bed. Prevents intermingling of gas and oil. Prevents intermingling and pollution of water.

Disadvantages: is expensive. Requires cleaning hole of oil where cement is placed, or makes likely poor cement in an oily hole.

Plugging shown in VI.

The type of plugging shown in VI. (fig. 34) embodies filling solidly as recommended by the Conference.

Advantages: allows no pocket for storage of gas under pressure. Shuts out gas, oil, and water from the coal-bed. Prevents intermingling of gas and oil. Is tight enough to resist heavy pressures.

Disadvantage: is expensive.

Discussion.

The tightness of the plugging shown in VI., fig. 34, is dependent largely on the use of wooden plugs and clay. The wooden plugs are preferred to the cement and clay because of the uncertainty as to the quality of cement when put into oily holes. To prevent the possible accumulation of gas in pockets the entire space between wooden plugs is to be filled in such a manner as to leave the smallest possible percentage of voids. These plugs and materials should be properly placed, and it is required that they be driven into place by drilling tools. A question was raised as to the necessity of filling entirely the holes between the wooden plugs prescribed, as there would be some localities where there would be great difficulty in obtaining proper material for filling. The requirement was, however, considered as fundamental for good work. The entire filling of the hole meets many of the requirements of others than the coal-operator, in that water-bearing measures as well as all gas- and oil-sands are thus protected. The avoidance of pockets

filled with gas is very necessary, as it is a matter of record that a relatively small quantity of gas drawn suddenly from an old well into a certain mine produced a serious loss of life by a resulting fire.

The mining interests were quite willing to forego more rigid requirements in other directions if they could feel assured that old holes were entirely and completely filled. It was pointed out that even if such plugging and filling should allow some gas to leak, the leakage would be at a relatively low rate, such that ventilation methods would care for it; whereas if there should be fear of an accumulated pocket of gas that might find sudden relief, the well would be considered a menace.

A well that is valueless for commercial purposes may produce gas slowly from deep-seated strata and at great pressure. If the borehole is open for 1000 or 2000 feet between plugs, forming a large pocket, the gas may gradually accumulate at a pressure approximating the original rock pressure. If a 10-inch hole is open for 1000 feet, it would contain at 60 atmospheres a volume of gas that would expand to 33,000 cubic feet if suddenly released. Such a relief might be found through the strata into a mine, and, mixing with the air of the mine, the gas might form 600,000 cubic feet of explosive mixture. If this should be ignited, a disastrous explosion might result; hence the great desirability of filling all cavities in which gas might accumulate.

Report of Plugging.*

The existence of either active or abandoned wells on a piece of property might be considered as an encumbrance on that property from the point of view of a coal-operator. In order, therefore, that the true state of this encumbrance should be known at any time, not only is it necessary that there be a record of the

* Art. IV. Sec. 6.

location, and of the method of casing through coal measures, but also a complete record should be available of the abandonment and plugging of the well.

MEASURING THE YIELD OF GAS-WELLS.

In measuring the volume of gas produced by a gas-well, the anemometer is generally used for wells whose output does not exceed 1,000,000 cubic feet daily. For measuring greater pressures a modification of the Pitot tube is employed. This modification is due to Prof. S. W. Robinson, who carried out a series of investigations on behalf of the Ohio Geological Survey in the Findlay field.

The pressure in the tube is read in inches of water or mercury, and the velocity in feet per second (v) is found from the following equation, where h is the height in inches of water (if the height be measured in mercury it must be multiplied by 13·5 to obtain the height of a corresponding water column).

$$v = 83{\cdot}1\,\sqrt{h}.$$

The daily discharge (V) in cubic feet will be represented by the formula—

$$V = 86{,}400\,va,$$

where a is the sectional area in feet of the delivery pipe.

YIELD OF GAS-WELLS.

As illustrating the productivity of some natural gas-wells, the following examples may be quoted :—

In 1907 a well, known as the Hoge well No. 1, drilled in Greene County, Pennsylvania, was considered to be the largest productive gas-well sunk in that State. Its capacity was estimated at between 50,000,000 and 60,000,000 cubic feet daily. The pressure in $5\frac{3}{16}$-inch casing was about 1000 lbs. ; the depth of the well was 2870 feet ; and gas was struck at 2860 feet.

In the same year two wells were "brought in" in the Caddo field in Louisiana with an estimated daily capacity of 35,000,000 to 50,000,000 cubic feet each.

A well drilled in Montgomery County, Kansas, in 1907, had a rock pressure of 325 lbs. and an output of 29,400,000 cubic feet per diem.

INITIAL DAILY PRODUCTION.

This term signifies the quantity of oil that a new well will yield the first day after it has been put, on the completion of drilling, into proper condition either for pumping or flowing.

"FLUSH PRODUCTION."

This term, as used in some of the states of the American Union, signifies the yield of a well during the first few days or the first few weeks, as the case may be, after oil has been struck and before the output has settled down to what may be regarded as usual for the field or district in which it is drilled. For example: If a well produced, after oil had been encountered, an average of 500 barrels per day for 10 days, and at the end of that time the production decreased to 50 barrels a day and was maintained at that figure for some time, the "flush" production would be represented by the average daily yield of 500 barrels.

"SETTLED PRODUCTION."

This term, as used in the United States of America, may be said to denote that a property in respect of which it is applied has had the requisite number of wells drilled on it. This production, apart from the normal progressive annual diminution, will last for a number of years.

"FOUNTAIN," "GUSHER," AND "SPOUTER."

These are practically synonymous terms, and are generally applied to those flowing wells from which oil is ejected with great force for a considerable time. "Spouter" properly implies a well from which the flow is intermittent and lasts for a short period only.

"FLOWING" WELL.

When the oil met with in a boring is associated with natural gas at sufficiently high pressure to force the liquid to the surface, the well is described as "flowing." The term includes all gradations from wells giving a feeble trickle to "fountains" yielding many thousands of barrels per diem; in practical use, however, the expression is generally limited to wells in which the pressure is sufficiently great to render pumping or other artificial means of bringing the oil to the surface unnecessary.

"WILD" WELL.

This term is used to denote a well which produces such quantities of oil or gas, or both, under such high pressure that it is either impossible to bring it under control or it is only controlled when a very considerable time has elapsed after the oil or gas has been met with. As examples, the oil-well at Dos Bocas, Mexico, and the gas-well at Kissarmas, Hungary, may be cited.

"DUSTER."

A colloquial expression used in the United States of America to designate a dry hole.

"ROILY" OIL.

This is a term applied in some parts of the United States of America to crude oil which has formed a more or less complete emulsion with water.

"WILD CAT" WELL.

"Wild cat" well, in the strictest sense of the term, is a boring located entirely by chance, without regard to geological or other indications. The classical instance is that of a prospecting party drilling on the spot where the waggon transporting their material broke down. The expression is, however, often applied loosely to exploratory borings in new territory, and even to those which have been located on scientific principles.

MEANING OF "SHELL."

In American drillers' terminology, "shell" or "shells" in a record of a boring means thin hard bands of limestone or other compact rock occurring at intervals in a mass of shale or clay. As thus used the word rarely, if ever, indicates fossil remains.

"TOUR."

A colloquial expression used by many drillers to designate a shift on a drilling well. "Morning tour" is the time of work from 12 midnight to 12 noon, the "afternoon tour" being from 12 noon to 12 midnight.

"SHUT DOWN."

A term used to denote that work on a well has been temporarily stopped.

"STANDING."

This term is also used in the same sense as "shut down," but as a general rule implies that the work has been discontinued for some considerable time owing either to a serious accident, to the desire to await the results of other wells being drilled in the vicinity, or to some more important cause than any of those to which a temporary stoppage of work may ordinarily be attributed.

"GO-DEVIL."

(1) A scraper with self-adjusting spring blades, inserted in a pipe-line, and carried forward by the fluid pressure, clearing away accumulations of paraffin, etc., from the walls of the pipe.—*Hawkins' Mechanical Dictionary.*

(2) In the oil country this term is applied to a device for exploding the nitro-glycerine used to "shoot" an oil well.—National Tube Co.'s *Book of Standards*, 1913.

HORSE-POWER.

One horse-power is the unit of power used by engineers, and a prime mover is said to be working with one horse-power when it exerts a force equal to 33,000 foot-lbs. per minute, *i.e.* when it would raise 33,000 lbs. through one foot in a minute. This estimate of the power of a horse was made by Watt, but it is rather above the capacity of an ordinary horse.

COST OF DRILLING WELLS BY CONTRACT IN ILLINOIS.

In Illinois the cost of drilling wells by contract is as follows :—

The price per foot to 1000 feet is 85 cents.
From 1000 feet to 1350, $1·20.
,, 1350 ,, ,, 1600, $1·35.
,, 1600 ,, ,, 2000, $1·50.

The contractor furnishes the drilling rig, tools, boiler, steam-engine, and water. He pays the producer $100 per well for fuel, either oil or gas. Should, however, oil or gas in excess of $100 be purchased by the contractor when drilling a well the producer pays the additional cost.

On the completion of a well the following rates are paid the contractor for withdrawing casing :—

20 cents per foot for $12\frac{1}{2}$-inch casing.
10 ,, ,, ,, 10 -inch ,,
10 ,, ,, ,, $8\frac{1}{4}$-inch ,,
6 ,, ,, ,, $6\frac{5}{8}$-inch ,,

After a well has been shot, the contractor receives $15 per day of twelve hours for time occupied in cleaning out the well, and he is paid at the same rate for any other work done at the well after the completion of drilling. For repairing and cleaning out old wells the usual charge is $20 per day, the contractor supplying the rig and tools, and the producer providing fuel and water.

PART V.

REFINING, TRANSPORT, STORAGE, AND TESTING.

REFINING PETROLEUM.

WHILE those who obtain the oil from the ground are generally able to dispose of the material in its crude state, in only a few cases is the purchaser the actual consumer (*e.g.*, for fuel or as a lubricant), for, as a general rule, the crude oil must undergo a process of refining before it can be utilised.

Considered broadly, the refining process is divided into two stages:—

(1) The separation of the crude oil into several fractions of varying character.

(2) The purification and standardising of these fractions for the market.

The first part of the process is carried out by means of distillation, the oil being thereby separated into naphtha or petroleum-spirit, illuminating oils, gas oils, lubricating oils, and such solid hydrocarbons as may be present, while a residue of fuel oil, asphalt, or coke is obtained. Formerly the distillation was completed in one operation, but it is now customary after having removed the lighter products to distil the residue for the production of lubricating oils and paraffin as a separate process.

Stills of various types have been and are used in fractionating petroleum, but the most usual form is that of a horizontal wrought-iron or steel cylinder. It is heated from below, and the vapour from the boiling oil passes through a pipe at the top to the condensers.

In order to increase the yield of the more valuable

products, by breaking up some of the oil intermediate between kerosene and lubricating oil, what is known as the "**cracking process**" is employed. This practically consists in distilling the oils at a temperature higher than the normal boiling-points of the intermediate constituents which it is desired to break up. The desired result may be brought about by distillation under pressure, or by allowing the condensed distillate to fall into the highly heated residue in the still. By this treatment the yield of kerosene from ordinary crude petroleum may be greatly increased.

In Russia, what is known as the **continuous system of distillation** is largely used. Here the crude oil is introduced at one end of a series or "**battery**" of horizontal cylindrical stills, and by an ingenious arrangement of pipes is passed on as the lighter products are distilled off, until only the heavy residue or **ostatki** remains to be drawn off from the last still.

The crude naphtha undergoes further fractionation in stills heated only by steam, while the lubricating oils are separated in special stills, the operation being now very generally carried out in a partial vacuum.

After the completion of the first stage of the refining process, the various products must be subjected to chemical treatment in order to remove impurities, which impart a dark colour as well as an unpleasant odour to the liquid, and, in the case of lamp oils, reduce the power of rising in the wick by capillary attraction.

This **purification** is carried out in two stages, the oil being first agitated with strong sulphuric acid and afterwards with a solution of caustic soda (soda lye). These processes are carried out in vertical cylinders with conical bottoms, known as **agitators,** the requisite agitation of the liquids being brought about either by compressed air or (on a smaller scale) by mechanical apparatus.

Lubricating oils are usually first freed from water by

being heated by steam-coils in small lead-lined agitators, after which the treatment is similar to that to which other oils are subjected.

TRANSPORT AND STORAGE.

The oil having been brought to the well's mouth, it must be stored, and arrangements must be made for conveying it to the nearest refinery, railway, or seaport.

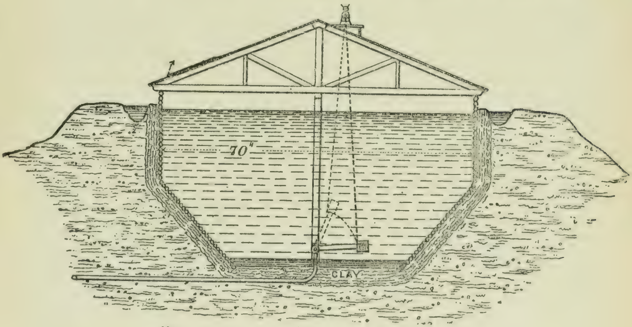


FIG. 35.—Earthen reservoir or "ambar."

For storing the oil as it comes to the surface, particularly in the case of an uncontrollable flowing well, it is often necessary to excavate **earthen reservoirs** or **"ambars."** These in their simplest form are far from satisfactory, since they permit the loss by evaporation of a large proportion of the lighter constituents. Fig. 35 shows the mode of construction of a more elaborate form of these reservoirs, wherein oil can be satisfactorily stored for a lengthy period.

The oil from pumping-wells is generally delivered into

small wooden or iron tanks, before being conducted by means of pipes into larger **storage-tanks.**

In small fields, the crude oil is often transported in **barrels** to the refineries, but these receptacles are more commonly used only for the products of petroleum.

For the transport of crude petroleum in bulk it is usual, where the output warrants it, to build **pipe-lines** from the field to the refinery or elsewhere. These are, where possible, so constructed that the oil will flow by gravitation from a high level at the field to a low level at the refinery, such a line being known as a gravity pipe-line. The pipes vary in diameter from 2 inches for the lines leading from the wells or small tanks to 8 or 10 inches for main lines.

Where a railway runs near the field, the transport of crude oil to a seaport or refinery is often carried out by means of **tank-cars,** these being constructed with horizontal boiler-plate tanks, furnished with a dome similar to that of a steam boiler. Fig. 36 shows a number of these cars at a railway siding, together with the arrangements employed for charging them. An orifice is provided in the top of the dome for filling, and a valve in the bottom of the tank for discharging.

Tank-barges, provided with masts and carrying a good spread of sail, are largely employed in the United States.

For marine transport in bulk of both crude petroleum and its products, **tank-steamers** are employed. Some of the more modern tank-vessels are furnished with Diesel engines as the source of power for propulsion.

Mr. B. Martell enumerates as essential features in the construction of tank-steamers :—

(1) Provision for the expansion of the oil under an increase of temperature.

(2) Provision for keeping each tank full by automatically supplying any loss due to leakage or to contraction consequent upon a fall in temperature of the oil.

FIG. 36.—Tank-cars and loading-rack

(3) Provision for the escape of the gases given off by the oil.

(4) Special precautions to prevent the passage of any of the oil into the boiler space.

STORAGE-TANK CAPACITIES.

Size of Tank.		Capacity.		
Diameter.	Height.	Imperial Gallons.	Tons of Kerosene. (Sp. gr. ·800.)	Tons of Fuel Oil. (Sp. gr. ·940.)
Feet.	Feet.			
20	15	29,368	105	123
25	15	45,887	164	193
30	20	88,104	315	370
35	25	149,899	535	629
40	25	195,787	699	821
45	25	247,793	885	1040
50	30	367,101	1311	1540
60	30	528,626	1888	2218
70	30	719,519	2570	3019
70	35	839,439	2998	3523
80	30	939,780	3356	3943
80	35	1,096,410	3916	4601
85	30	1,060,924	3789	4452
85	35	1,237,745	4421	5194
90	30	1,189,409	4248	4991
90	35	1,387,644	4955	5823

TO FIND THE CAPACITY OF A CYLINDRICAL TANK IN CUBIC FEET.

Multiply the square of the diameter of the tank by ·7854, and the product multiplied by the height of the tank in feet equals the cubic contents in feet.

Example.—What is the cubic contents in feet of a tank 90 feet in diameter by 30 feet in height ?

Diameter squared $= 90 \times 90 = 8100$.

$8100 \times {\cdot}7854 = 6361{\cdot}74 \times 30 = 190852{\cdot}2$ cubic feet.

PIPE-LINES.

Trunk lines in the United States usually vary from 4 to 8 inches in diameter. They are made up in 18-foot lengths of specially made and tested lap-welded wrought-iron pipe known as "oil-line pipe." The lengths are connected by long sleeve couplings, cut, as are the ends of the pipes, with coarse and sharp taper threads, nine to the inch, the taper being usually $\frac{3}{4}$ inch to the foot for 4-inch pipe. The lines are usually laid two or three feet below the surface of the ground, and are provided at intervals with bends, to allow for expansion and contraction under changes of temperature.

The pipes are kept clean by means of a "go-devil," an automatic rotary scraper forced through with and at the same speed as the oil (about 3 miles per hour). The instrument has a ball and socket joint at the centre to permit of its passing the bends of the pipe. The spindle is fitted with radial steel blades, which scrape the pipe, and with oblique vanes, which cause it to rotate as it advances. There are three arms at each end to keep it in its proper position in the pipe.

The pumps now employed are of the Worthington type, the distance between the stations varying with the "head" to be overcome on account of the incline of the pipe and resistance due to friction.

To ascertain the weight of oil in pipe-lines, tubing, or

casing, square the diameter of the pipe in inches, and the result will be the weight of water in pounds avoirdupois to the yard. Multiply the weight of the water by the specific gravity of the oil, and the product will be the weight of the oil.

Doubling the diameter of a pipe increases its capacity four times.

FLOW OF GAS IN LONG PIPES UNDER HIGH PRESSURE.

A = Atmospheric pressure, lbs. per square foot absolute.
P = Initial pressure of gas " " "
p = Final " " " " "
T = Temperature of gas, absolute, Fahrenheit.
L = Length of pipe, feet. D = Diameter of pipe, feet.
V = Volume of 1 lb. of gas at atmospheric pressure.
U = Velocity of gas, feet per second.
M = Hydraulic mean depth (for circular pipe M = D ÷ 4).
Σ = Coefficient of friction = ·0027 (1 + ·3D) (Unwin, for air).
g = Gravity = 32·2. c = AV ÷ T.

$$U = \sqrt{gcT(P^2 - p^2) \div P^2\left(\Sigma\frac{L}{M} - \log_\epsilon \frac{P}{p}\right)}.$$

Q = Quantity of gas = ·7854 UD² cubic feet.

The value of Σ for gas is for all practical purposes the same as for air.

When L is large, the item $\log_\epsilon \frac{P}{p}$ can be omitted.

Molesworth.

PUMPING ENGINES.

G = Thousands of gallons raised per 24 hours.
g = Gallons delivered per minute = ·002833 D^2SN.
F = Thousands of cubic feet raised per 24 hours.
f = Cubic feet of water delivered per minute = ·0004545 D^2SN.
p = Lbs. of water delivered per minute = ·02833 D^2SN.
S = Stroke of pump in inches.

N = Number of strokes per minute.
D = Diameter of pump in inches.

$$=47\sqrt{\frac{f}{SN}};\ =19\sqrt{\frac{g}{SN}};\ =5{\cdot}94\sqrt{\frac{p}{SN}}.$$

The area of the pump should be increased by about 25 per cent. to allow for leakage, etc.

The theoretical horse-power $= \cdot 00021$ GH; $= \cdot 00131$ FH.

The actual horse-power should be increased by about 20 per cent., and to this it is usual to add 50 per cent. or 60 per cent. to allow for contingencies, leakage, etc.

Molesworth.

RAILWAY TANK-CARS.

In the United States of America modern tank-cars of capacities of over 8000 U.S.A. gallons are placed on steel underframes of standard dimensions with bogie trucks.

Description of Standard Steel Underframes for Tank-Cars.

General Dimensions.	10,000 Gallons and under.		Over 10,000 Gallons.	
	Ft.	Ins.	Ft.	Ins.
Length over striking plates .	32	4	37	4
Width over side sills between bolster and sills . . .	9	2	9	2
Height, top of rail to centre of coupler	2	$10\frac{1}{2}$	2	$10\frac{1}{2}$
Centre to centre of trucks .	22	3	27	3
Height, top of rail to bearing-surface of centre plates .	2	$1\frac{5}{8}$	2	$1\frac{5}{8}$
Height, top of rail to top of platform	3	$5\frac{5}{8}$	3	$5\frac{5}{8}$

These underframes are provided with automatic couplers, automatic air-brakes of approved standard designs, and a hand-brake operating in the same direction as the air.

THE TANKS.

For a capacity of 10,000 U.S.A. gallons or under, the tanks are made 28 feet long from centre of head rivets; for capacities over 10,000 gallons the standard length is 33 feet, the diameters varying with the capacity.

The shell of these tanks is made of riveted steel sheets as follows :—

The bottom plate of one single sheet of $\frac{3}{8}$-inch steel, 80 inches wide.

The upper plates of $\frac{1}{4}$-inch or $\frac{5}{16}$-inch steel sheets in five courses.

The heads of $\frac{3}{8}$-inch or $\frac{7}{16}$-inch steel sheets, dished to a 10-feet radius.

The dome, constructed of the same material as the upper part of the shell, is 22 inches high, the diameter varying with the capacity of the tank in order to allow for a minimum expansion space of 2 per cent.

If volatile and inflammable material is to be transported, one safety-valve is required for tanks holding less than 6600 U.S.A. gallons, and two safety-valves for tanks of larger capacity In the former case the valve is set to open at 8 lbs. pressure ; in the latter, where two valves are used, one is set for 8 lbs. and the other for 12 lbs.

Steam-pipes to heat the contents are provided when required. The outlet valve, placed in the centre of the bottom of the tank, is of 6 inches diameter, and is provided with a removable cap and plug operated by means of a rod and cam from the inside of the dome.

All tanks are tested to a pressure of 60 lbs. to the square inch, and are constructed to stand a bursting pressure of 240 lbs. to the square inch.

The tanks are fastened to the underframes in a manner to prevent end-shifting of the tank and allowing for independent expansion of the tank and underframe due to differences of temperatures.

TRANSPORT OF PETROLEUM IN BARRELS.

An ordinary barrel is 33 inches long and 25 inches in diameter at middle. . . . Such a cask holds about 42 imperial gallons, and its own weight is 64 lbs. or one-fifth of that of contained oil. It is estimated that in stowing this cargo $3\frac{1}{2}$ casks take up on the average a ton of 50 cubic feet, and it would therefore occupy 80 cubic feet per ton deadweight. But as most modern three-deck steamers, fitted with water ballast in the holds in the usual way, cannot be brought to their load draught with cargoes occupying more than about 50 cubic feet to the ton, it will be seen that a great loss of cargo-carrying power is sustained by shipping petroleum in such vessels as casks, through the fact that the whole of the available cargo space is occupied long before the vessel is brought down to the proper load draught.—*Martell.*

The transportation of oil in barrels is being discontinued, especially in respect to sea-borne cargoes. Wooden barrels, however, are largely used in many countries for the transportation, on railways and by road, of kerosene and lubricating oils, and steel barrels, electrically-welded or otherwise, are extensively employed for the lighter petroleum products.

According to the rules of the New York Produce Exchange, petroleum barrels should be made of well-seasoned white oak, and should be bound by either six or eight iron hoops. When six hoops are used, the head hoop should be $1\frac{3}{4}$ inch wide, No. 16 gauge (English standard); the quarter hoop $1\frac{1}{2}$ inch wide, No. 17 gauge; and the bilge hoop $1\frac{3}{4}$ inch wide, No. 16 gauge. When eight are used, the head hoop should be $1\frac{3}{4}$ inch

wide, No. 17 gauge; the collar hoop $1\frac{1}{4}$ inch wide, No. 17 gauge; the quarter hoop $1\frac{1}{2}$ inch wide, No. 18 gauge; and the bilge hoop No. 18 gauge. All old barrels the gross (full) weight of which is less than 395 lbs., may be hooped by six hoops $1\frac{1}{2}$ inch wide, excepting the chime hoop, which should be $1\frac{3}{4}$ inch wide. Barrels are divided into three classes—(1) capable of carrying refined petroleum or naphtha; (2) unfit for such purpose, but suitable for carrying crude petroleum; and (3) suitable only for residuum.

TO FIND THE CAPACITY OF BARRELS OR CASKS.

D, d = Inside diameter at heads in inches.
M = ,, ,, ,, bung ,,
L = Length in inches.

The capacity in imperial gallons. $= \cdot 0014162\, L(Dd = M^2)$.

TESTING PETROLEUM.

A large number of physical and chemical tests are applied both to crude petroleum and to the products manufactured from it. The industry is conducted upon a basis of recognised standards of quality, and testing is necessary on the one hand to satisfy the refiner that his processes are being properly conducted, and on the other to protect the buyer. Moreover, certain products are required to conform to statutory and municipal regulations, and prescribed tests have to be applied in connection with these restrictions. The following are the chief tests applied:—

Specific Gravity.—The weight as compared with water is generally determined for all liquid products of petroleum. In the United States this is expressed in degrees of Baumé's hydrometer, on which water registers 10°. Some confusion is occasioned by the fact

that the lighter the oil the greater the number of degrees indicated (see table, page 165), thus, what is spoken of in the United States as a "high gravity" oil might be called in other countries an oil of "low gravity"; both terms being equivalent to "low density," meaning an oil much lighter than water.

Composition.—To ascertain the proportion of the different classes of products present in crude oil, and to determine certain special points in regard to some of these products, the oils are submitted to fractional distillation, this being, in the case of crude oils, practically equivalent to carrying out the first stage of the refining processes on a small scale. The percentage distilling below 150° C. is regarded as that of benzine, and the percentage distilling between 150° and 300° C., or with some crude oils a lower maximum temperature, as that of kerosene.

In the case of fuel oils it is usual to ascertain the freedom from water and solid matter, the flash-point, the fluidity (as indicated by the viscosity) at a temperature of 32° F., and the percentage of sulphur.

Flashing-point and Fire-test.—The temperature at which a mineral oil, on being slowly heated, begins to evolve vapour in such quantity that on the application of a flame (the "test-flame") a momentary "flash," due to the ignition of the vapour, occurs, is termed the "flashing-point" or "flash-point"; and the temperature at which, on being further heated, the oil takes fire on the approach of a flame, and continues burning, is described as the "fire-test" of the sample under examination.

One or both of these temperatures is generally determined in the case of crude oils from new districts, mineral colza oil, solar oil distillate, lubricating oils, and residues; while in the case of kerosene (illuminating oil) or paraffin oil (from shale) this testing of the "flashing-point" or igniting-point is of the greatest importance,

and forms the basis of legislation on petroleum in most civilised countries.

Several instruments have been designed for carrying out these tests, but the form most commonly used and recognised by law is that invented by Sir Frederick Abel, or the modification of this, known as the Abel-Pensky instrument, a full description of which will be found in *Petroleum* (Charles Griffin & Co., Ltd.). For the determination of the "flashing-point" of lubricating oils a further modification, known as the Pensky-Martens tester, is used.

Test-tube Method of Testing.—When only a small quantity of oil is available for testing, the flashing-point may be approximately determined by slowly heating the oil in a test-tube 4 or 5 inches in length by about three-quarters of an inch in diameter, and inserting the burning end of a piece of thin twine into the mouth of the tube at intervals, after agitating the oil. The tube should be about one-third filled with the oil, and a delicate thermometer used to take the temperature. In this way results, which do not differ materially from those furnished by the Abel instrument, may be obtained after a little practice.

Colour.—Rough determinations of colour may be desirable in the case of crude oils from new territory and lubricating oils, but the colour of kerosene and mineral colza oil is determined in relation to glass standards, being generally expressed as :—

1. Water white.
2. Superfine white.
3. Prime white.
4. Standard white.

Odour.—No exact standards exist for recording the odour of oils, but it is often an important point. A general description as "pleasant," "unpleasant," "sulphuretted," etc., is given in the case of crude oils. Deodorised American petroleum spirit should leave no unpleasant odour when it is evaporated on the hand.

In the case of kerosene the odour is reported as "good-merchantable" or "not good-merchantable."

Viscosity.*—The viscosity, *i.e.* the rate of flow through a small orifice, is now regarded as one of the most important characters of a mineral lubricating oil, and several forms of apparatus for determining it are in use.

Calorific Value.—It is often needful to determine this in reporting upon samples of oil fuel or crude oils capable of being used as liquid fuel.

The determination is made by burning a small quantity of the oil in a closed *calorimetric bomb* in the presence of an excess of oxygen, the bomb being immersed in water contained in a calorimeter so that the heat generated can be measured; the value of the oil as fuel being thus indicated.

Burning Quality.—To ascertain their comparative values for illuminating purposes, oils are burned in lamps with standardised wicks, but no general agreement has been arrived at as to the manner in which the results should be expressed.

Cold-test.—The "cold-test" of "pale" lubricating oil is usually considered to be the temperature at which the separation of solid hydrocarbons commences on a gradual reduction of temperature; and of "black" oils, the point at which the oil ceases to flow when slowly cooled.

Melting-point.—This is required to be stated in the case of paraffin wax, and is understood commercially to be the temperature at which the liquefied paraffin commences to solidify.

BROMINATION OF OILS.

Bromine is readily absorbed by hydrocarbons of the olefine group, but has no action on paraffins or naphthenes.

* See Viscometry, p. 166.

hence it affords an indication of the proportion of olefines present.

The following method of applying the test to commercial products from shale and petroleum is recommended by Mr Allen (*Commercial Organic Analyses*, 2nd ed.) :—

An approximately decinormal solution of bromine is made by dissolving 2 c.c. of bromine in 750 c.c. of recently distilled carbon bisulphide, and the solution, having been dried by adding some lumps of fused calcium chloride, is preserved in the dark. From 0·3 to 1 gram of the oil, or a certain volume of a solution of the oil in carbon bisulphide containing a known amount of the oil, is weighed or measured out in a perfectly dry stoppered flask or separator, and the solution is diluted, if necessary, with carbon bisulphide (dried over calcium chloride) to about 25 c.c. Then 25 c.c. of the bromine solution is added, and the flask is stoppered, agitated, and left in the dark for a quarter of an hour. If the liquid is not distinctly red after the agitation, a further quantity of the bromine solution is added without delay. After a quarter of an hour an excess of an aqueous solution of potassium iodide is poured in, and the mixture is agitated. The bromine which was not absorbed by the oil having thus been replaced by an equivalent amount of free iodine, the flask is removed to a light place and the contents titrated with a decinormal solution of sodium thiosulphate, made by dissolving 24·8 grams of the crystallised salt in one litre of water. The titration is conducted in the usual manner, the final change being rendered more sharp by adding a few drops of starch solution when the bisulphide is nearly decolorised. The bromine solution used requires to be occasionally standardised by treating 25 c.c. of its solution in carbon bisulphide with potassium iodide, and titrating exactly as above. The difference between the volume of thiosulphate now required, and that used after treating the

oil, represents the volume corresponding with the amount of bromine absorbed. One c.c. of the thiosulphate solution should correspond with 0·008 gram of bromine. If the crystalline thiosulphate used be pure, and be crushed and dried between blotting-paper before being weighed out, the solution will contain so nearly the right proportion of salt that, if it be required for ordinary use, there is no necessity to standardise it by iodine. It is found that if the bromine treatment of the oil be allowed to proceed in the light (even if diffused) a markedly larger quantity of bromine is absorbed.

Part VI.

USES.

USES.

Crude oil and the products therefrom are used for many purposes, too numerous to specify in detail. The main uses, however, are for lighting, heating, lubrication, and the creation of power.

USES OF PETROLEUM AND ITS PRODUCTS.

The following are the chief products of petroleum, with the principal uses to which each is put :—

Crude Petroleum.—Many varieties of mineral oil have been used at various times for pharmaceutical purposes, both with and without suitable purification. The product known as *ichthyol*, manufactured from a mineral oil obtained by distillation from a fossiliferous bituminous mineral found in the Tyrol, is a valuable constituent of certain ointments.

Crude petroleum is commonly used as fuel for steam-raising in the various oil-fields, and in some instances contains so small a percentage of the more volatile hydrocarbons that it can be used for general industrial purposes; usually, however, these hydrocarbons have to be removed by distillation before the oil is suitable for use as liquid fuel (*see* **Residuum**). In some cases the fuel oil is a distillate.

Crude oil can also be used in the manufacture of oil-gas and carburetted water-gas (*see* **Gas-oil**), while the more viscous descriptions are used as lubricants, and

have been found specially suited for use in the Elmore process of ore-concentration by oil.

Petroleum Spirit.—The more volatile hydrocarbons of petroleum, constituting the commercial products known as *gasoline*, *benzine*, and *petrol*, are widely used both in special forms of lamps and in internal combustion engines. The growth of the automobile industry has created an enormous demand for petroleum spirit. Gasoline is also used in the production of "air-gas," or carburetted air, for illuminating purposes and in stoves for cooking and heating.

The very volatile product of petroleum known as *rhigolene* has been found to be a valuable local anæsthetic.

Kerosene.—This product is the most important form of illuminating agent derived from petroleum: being similar to the "paraffin oil" obtained from the oil-shales of Scotland, and often consisting mainly of hydrocarbons of the paraffin series, it is very commonly referred to under that name. For a description of the various forms of kerosene-lamps larger works should be consulted.

Kerosene is now used in some forms of internal combustion engines, and in the manufacture of gas.

Gas-oil.—The oils intermediate between the burning and lubricating oils in respect to boiling-point and density are known in Scotland, the United States, and elsewhere, as gas-oil; the similar oil obtained in Russia being termed *solar oil distillate*. As the name implies, these oils are used in the manufacture of gas, and in the enrichment of coal-gas, the oil being converted into permanent gas in special retorts.

Lubricating Oils.—The very general and increasing substitution of mineral oils for fixed oils and greases in the lubrication of machinery and the rolling-stock of railways indicates the importance of this application of petroleum products. For some purposes preference is given to "compound oils," which are mixtures of mineral and fixed oils, but for the lubrication of steam-engine

cylinders a pure hydrocarbon should always be used, as in the presence of high-pressure steam fixed oils are decomposed, with the production of free fatty acids, and subsequent formation of metallic soaps.

Residuum.—The residuum of petroleum after the removal of the lighter portions by distillation, known in Russia as *ostatki*, is largely used as fuel, and developments of the use of petroleum in this way are likely to play an important part in the economic progress of many countries.

Paraffin.—The paraffin candle has so completely superseded the old tallow "dip," and the beautiful translucent candles of white paraffin (manufactured in many artistic forms by Price's, Limited, and others) are so commonly employed, that it is unnecessary to point out how important the solid hydrocarbons contained in petroleum and shale-oil have become to the candle-maker. Paraffin of low fusing-point is also burned in specially constructed lamps.

Paraffin is used in the manufacture of wooden matches, the combustibility of the wood being increased by saturating it with the melted material, and it has been applied as a thin coating to the heads of matches to render them waterproof. Dr. Stenhouse has patented the application of paraffin to woollen fabrics, to impart additional strength and make them waterproof. In Java, paraffin is employed by manufacturers of coloured textile materials in tracing designs with it on the fabric before immersion in the dye. It has been used for lining beer barrels, and is employed for glazing frescoes and paper, for saturating gypsum and fluor-spar before turning them in the lathe or otherwise shaping them into ornaments, and in starching linen to produce a gloss. Of recent years, paraffin, as well as mineral oil, has been used in laundry work, as an auxiliary to soap, on account of its detergent action. Paraffin is also employed as a preservative for stone and

wood, and it forms a good protective coating for the labels and stoppers of bottles used for corrosive liquids. It is used in preserving eggs, and may be similarly applied as a preservative coating to meat, fruit, and flowers. The models of ships to be tested in naval experimental tanks are moulded in paraffin. Refined ozokerite is employed by French perfumers as a substitute for lard in the process known as "enfleurage," the almost entire solubility of hydrocarbon in alcohol, and its non-liability to become rancid, giving it a great advantage over the animal fat. Paraffin forms an excellent electric insulator, and Mr. Joly found that a good photometer disc-substitute may be made by placing a sheet of tin foil between two suitably shaped blocks of paraffin.

Vaseline.—The amorphous jelly-like hydrocarbons obtained from Pennsylvanian, Galician, Alsatian, and Russian petroleums are very largely employed, both alone and as a vehicle for the external application of medicinal agents, especially when local action, rather than absorption, is desired. The physical and chemical characters of vaseline indicate the superiority of this product over an animal fat for such purposes.

Vaseline affords a good protective covering for the surface of oxidisable metals, and as such is used to a very considerable extent.

Asphalt.—The use of asphalt for paving is well known, the substance commonly used being a mixture of asphalt with limestone or other suitable material, or a pulverised rock, which is found in its natural state saturated with inspissated petroleum.

Some forms of solid bitumen are employed in the manufacture of varnishes.

Mineral Colza Oil.—Sp. gr. 0·825 to 0·830. Flash-point 250° F. (Abel).

Pentane.—Sp. gr. 0·625. Boiling-point 76° to 128° F. Used as a standard of light in photometric work.

Paraffinum Liquidum.—Colourless and inodorous oil, of sp. gr. 0·880 to 0·885, used for pharmaceutical purposes.

OIL FUEL.

One of the most important uses to which crude petroleum and its products are put is as fuel for steam-raising purposes, and in internal combustion engines. The advantages of liquid fuel over coal are numerous, and may be summarised as foilows :—

1. Has greater calorific value.
2. Is more easily handled.
3. Requires less labour.
4. Occupies less space.
5. Steam pressure is easier of control.

Oil fuel is successfully employed in locomotive, marine, and all kinds of stationary boilers, for metallurgical purposes, in household stoves, etc. Benzine, kerosene, various distillates, and crude oil, are employed in internal combustion engines of different kinds. The more extended use of oil fuel at the present time is impeded only by the comparatively limited supply, and high price.

It is generally considered that taking everything into account the consumer can afford to pay for oil fuel twice the price that he pays for coal, on the assumption that the oil is to be used in steam-raising. If the oil is employed as a source of power in internal combustion engines of the Diesel type, the comparison is far more favourable, for whereas the steam-engine ordinarily furnishes about 12 per cent. of the energy of the fuel in the form of work, the Diesel engine gives as much as 37 per cent. Recent improvements have, however, largely increased the efficiency of the steam-engine, and this must now be taken into account in estimating the superior efficiency of the Diesel engine.

In 1911 in the United States about thirty railway companies were using oil fuel on their lines. The Southern Pacific had over 1200 oil-burning locomotives in use; the Santa Fe over 800; the Northern Pacific 20; and the Great Northern 115.

COMPOSITION OF GOOD OIL FUEL.

On analysis a good oil fuel is found to have the following percentage composition :—

Carbon	87·80
Hydrogen	10·78
Oxygen	1·24

and calculating the evaporating power from this analysis, it will be $0{\cdot}15\ (87{\cdot}8 + 4{\cdot}28\left(10{\cdot}78 - \frac{1{\cdot}24}{8}\right)) = 19{\cdot}9$ lbs. of water from and at 212° F. As determined in the bomb the calorific value is 18,831 B.Th.U., and if this figure be divided by 966 (the latent heat of steam in ° F.) the evaporative power is obtained as 19·5, so that one may assume that under theoretical conditions the evaporation per pound of oil would be about this quantity.

Vivian B. Lewes.

PARTICULARS OF OIL FUELS.

Description.	Specific Gravity.	Flash-point.	Calorific Value by Bomb.		Actual Evaporative Power in Practice from and at 212° F.
			Calories.	B.Th.U.	
American residuum .	·886	350	10,904	19,627	15·0
Russian ostatki .	·956	308	10,800	19,440	14·8
Texas . . .	·945	244	10,700	19,242	14·79
Burma . . .	·920	230	10,480	18,864	14·5
Barbados . .	·958	210	9,899	17,718	14·2
Borneo . . .	·936	285	10,461	18,831	14·0
Shale oil . .	·875	288	10,120	18,217	13·8
Blast furnace oil .	·979	206	8,933	16,080	12·0
Heavy tar oil . .	1·084	218	8,916	16,050	12 0

QUANTITY OF AIR REQUIRED FOR COMBUSTION OF FUEL.

Fuel.	Air per Kilo.	Air per Lb.
	Cubic M.	Cubic Ft.
Coke	10·09	162·06
Coal (anthracite)	9·01	144·60
,, (bituminous)	8·93	143·40
,, (coking)	8·68	139·41
,, (cannel)	8·79	141·07
,, (smithy)	7·67	123·15
Charcoal	8·53	133·90
Lignite	7·02	112·43
Peat, dry	5·75	92·36
Wood, dry	4·57	73·36
Petroleum	10·76	172·86
Natural gas	14·20	227·93
Coal gas	14·51	233·06
Water gas	3·16	50·70
Producer gas	·72	11·56

Lewes.

COMPARISON OF FUEL CONSUMPTION BY VARIOUS TYPES OF ENGINES.

(H. W. van Tyen.)

Type of Engine.	Fuel.	Consumption. Lbs. per E.H.P. Hour.
Reciprocating engine	Coal.	1·54
Steam turbine	Coal.	1·49
Suction gas-engine	Anthracite.	0·825
Explosion motor	Petroleum.	0·725
Explosion motor	Benzine.	0·66
Diesel engine	Heavy oil.	0·44

LIQUID FUEL BURNERS.

The simplest system of burning liquid fuel under stationary boilers is that suggested by Mr Ludwig Nobel, in which the oil flows from the top to the bottom of a series of superimposed shallow troughs placed at the door of the furnace. The troughs are separated sufficiently to admit of the entrance of a current of air, which sweeps over the surface of the burning oil and carries the flames into the furnace.

It is, however, more common and convenient to burn the oil by means of an injector, which drives the fuel

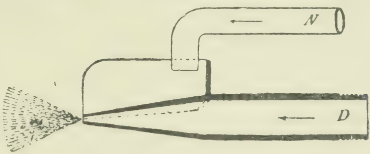


FIG. 37.—Liquid fuel burner.

into the combustion chamber in the form of spray, together with the amount of air necessary for its combustion. Many forms of injector * are in common use, and these may be arranged in three groups, according as the oil is sprayed by means of

(1) Steam.
(2) Compressed air.
(3) Pressure.

Class I. In Russia a very simple form of burner of this type, shown in fig. 37, has been used. The fuel (ostatki) enters at N, the size and shape of the flame depending upon the shape of the mouthpiece of the steam-pipe D. More complicated forms are the Kermode

* See *Oil Fuel*, by Ed. Butler (Charles Griffin & Co., Ltd.).

steam burner, the Holden, Brandt, Lenz, Sandgreen, Rusden-Eeles, Orde, and other burners.

Class II. In Curle's, or the "Carbogen," burner there are three concentric nozzles, the innermost and outermost for air, the intermediate one for fuel.

In the Kermode hot-air burner the oil and air travel together to the nozzle.

Class III. includes the Kermode pressure jet burner, the Meyer, Körting, Swensson, Thornycroft, and Gordejeff.

OIL-ENGINES.

In modern oil-engines other than those of the Diesel type the charge of oil taken from the supply-tank is converted into vapour or spray, which is carried by a current of air into the cylinder, where it is mixed with the residue of the products of combustion of the previous charge and with excess of air for combustion. This mixture is compressed and ignited. During explosion the burning gases expand, doing work on the motor piston, and are finally ejected as in the gas-engine.

The majority of oil-engines are constructed on the four-stroke-cycle principle, first enunciated in 1862 by M. Beau de Rochas, a French engineer, and commonly known by his name. In this system, which is also termed the Otto cycle, there is only one impulse to every four consecutive strokes, or every two revolutions of the crank. The first stroke draws in the charge of petroleum vapour and air, the second compresses the charge, at the commencement of the third, which is the effective stroke, the charge is ignited, with resulting explosion and expansion, and the fourth, termed the scavenging stroke, discharges the products of combustion from the cylinder.

Robinson (1902) divided oil-engines into four classes, while the advent of the Diesel oil-engine creates a fifth class, employing heavier oils than those used with the earlier engines, even crude oil being successfully employed.

Class I. The measured charge of oil is sprayed by compressed air into a vaporiser, heated by the exhaust gases, and the vapour is carried by the charge of air past the admission valve into the motor-cylinder, where the mixture is further heated by the residual products and cylinder walls, compressed and fired, as in the Priestman and Griffin engines.

Class II. The oil as injected by a pump in fine jets is sprayed into the residual products of combustion and air contained in a red-hot cartridge or vaporiser always open by a narrow neck to the end of the motor-cylinder. The oil vapour is mixed with excess of air, which is admitted to the cylinder by a separate valve, and the air is compressed by the motor-piston into the red-hot vaporiser and clearance space forming the combustion chamber, where the mixture is fired by compression against the heated surface, as in the Hornsby-Akroyd engine.

Class III. (*a*) A small vaporiser is kept red-hot by the flame from a lamp which also heats the ignition tube, and the measured charge of oil is delivered by a pump and sucked through the vaporiser with a little hot air to carry the oil vapour through a separate valve into the cylinder, where it is mixed with the residual products, and the main supply of cold air is drawn through another valve. Examples — the Trusty, Clayton and Shuttleworth, Crossley, Fielding, Gardner, Howard, Blackstone, and other oil-engines.

(*b*) The oil is allowed to drop on a heated surface, and is swept along with the larger part of the charge of air previously heated, and then drawn through a vaporiser and admitted by a valve into the motor-cylinder, where it is mixed with the burnt products and little or no additional air. Examples—the Roots and Premier oil-engines.

Class IV. Each charge of oil is drawn in with the whole charge of cold air by the valve through the vapor-

iser into the combustion chamber. The combustible mixture is compressed and ignited as in Class III. Examples—the Tangye and Campbell oil-engines.

Class V. The liquid oil is injected through a spraying nozzle in finely divided particles into a large excess of air, highly heated by compression, in the motor-cylinder, where the mixture ignites spontaneously. Example—the Diesel engine.

The Diesel engine has now been successfully applied to the propulsion of ships, and by some authorities preference is given to a two-stroke-cycle form, with separate pump.

The Diesel engine has been found to furnish 37 per cent. of the energy of the fuel employed in the form of work, while the ordinary type of internal combustion engine gives 25 per cent. and the ordinary steam-engine only 12 per cent.

USE OF NATURAL GAS IN THE UNITED STATES OF AMERICA.

In the United States three products have been obtained directly from natural gas, viz. gasoline, lampblack, and gas-coke, but the manufacture of the latter was discontinued when natural gas began to be consumed in an efficient and economical manner. The conversion of natural gas into lampblack is still carried on in a few districts, but the process is a most wasteful one, as the percentage of carbon obtained is probably little more than one-twentieth of that contained in the gas. In the manufacture of lampblack a number of small jets of burning gas are caused to play upon circular sheets of iron, or upon a 2-inch pipe, through which water is circulated, and the deposit of carbon is removed by means of scrapers and brushes.

Apart from its general use for lighting and heating, in the same manner as that in which coal-gas is utilised in this country, natural gas has been employed in steam-engines, and in some cases in pumps, the gas pressure

being substituted for steam pressure—a practice, however, which is prohibited by law in most states. In the oil-fields the gas is largely used in gas-engines for pumping wells and for raising steam in drilling-boilers.

In addition to its consumption as a source of power, natural gas is used to a considerable extent as a source of heat in the manufacture of iron, glass, bricks, tiles, cement, etc. In West Virginia it is largely employed in the manufacture of lampblack, and in Kansas by zinc smelters.

Recently a number of plants have been erected in several states for the extraction of gasoline from oil-well gas. Such statistics as are available as to the quantity of gasoline which can be obtained from 1000 cubic feet of gas are given in Part IX. There can be little doubt that this practice will extend to other countries possessing a supply of suitable gas.

In Texas a trial has been made of natural gas for firing a locomotive. As the experiment suggests considerable potentialities in this direction, the following particulars are taken from *The Production of Natural Gas in 1910*. U.S. Geological Survey :—

"In the year 1910 natural gas was used in Texas for fuel on a short railroad about 7½ miles long, running from Bloomberg, on the Kansas City Southern Railroad, to Atlanta, there being a natural-gas line at each end of the road. It was demonstrated that steam could be raised quicker with the gas than with coal and would haul the same load, but the results were not entirely satisfactory on account of the increased danger to the trainmen, and because the pressure of the gas was not high enough in the pipe-line to give the pressure that was required in the drum.

"A gas drum or tank, 6 feet in diameter and 36 feet long, was loaded on a flat car, which was coupled to the rear of the locomotive, and connected by pipes with the firebox. A burner having 36 openings, through which

the gas escaped as it was used, was placed on the grate bars, with about 6 inches space between the burner and the walls of the box. Gas was charged into the tank with natural-gas pressure, which was about 100 lbs., and was then connected to the gas-burner in the firebox and regulated by a valve in the cab, which was handled by the fireman.

"The gas was used successfully for about five months, but at the end of that time an inexperienced fireman was put on, and while stopping at one of the stations, instead of cutting the gas down, which was what he should have done, he made a mistake and turned the gas on. The fire door was kept in the second notch, which permitted the fireman to see inside and know how the combustion was, and the gas also seemed to burn better with the door open this much. When the fireman turned the gas on instead of turning it off, the blaze came out of this space at the door and filled the cab with flames. Both the fireman and the engineer jumped off, and the latter shut off the gas at the tank. Neither of the men was seriously burned. After this the gas was used successfully for at least thirty days. In the meantime the company decided that it would not like to run the risk of this happening again, and would discontinue the use of gas and return to coal."

ASPHALT.

For use in street paving an asphaltic cement is used in combination with either broken stone of the ordinary type, or with mineral matter such as sand, powdered limestone, etc.; in the former case the asphalt merely plays the part of a road-binder, in the latter the surface is covered with a layer of the asphalt.

The asphaltic cement for paving is obtained by combining native asphalt, such as that of Trinidad, with a heavy oil, or a residue from the refining of petroleum, these materials being known as fluxes.

When a substance like the asphalt-rock of the Val de Travers, a limestone strongly impregnated with bitumen, is employed, the native material is reduced to powder and a suitable flux added, no additional mineral matter being required. This mixture, known as "mastic," should contain about 15 per cent. bitumen and 85 per cent. mineral matter.

Native asphalts are subjected to a process of refining, consisting in drying the material to free it from the water, which forms a kind of emulsion with the bitumen in the crude state.

ANALYSES OF REFINED NATIVE ASPHALTS.

CALIFORNIA.

La Patera.

	Per cent.
Penetration*	0·0
Bitumen soluble in CS_2	49·3
Pure bitumen soluble in 88° naphtha	43·8
Pure bitumen as saturated hydrocarbons	8·1
Sulphur	6·2
Residual coke, ash free	14·9

CUBA.

Bejucal.

Penetration	0·0
Bitumen soluble in CS_2	75·1
Pure bitumen soluble in 88° naphtha	43·1
Pure bitumen as saturated hydrocarbons	17·0
Sulphur	8·3
Residual coke, ash free	25·0

* The consistency of an asphalt or asphalt cement is determined by the depth in hundredths of a centimetre to which a No. 2 cambric needle will penetrate in 5 seconds, under a weight of 100 grammes, at a temperature of 77° F. The Dow penetration machine, or the New York Testing Laboratory penetrometer, may be used for this purpose.

TRINIDAD.

	Per cent.
Penetration	7·0
Bitumen soluble in CS_2	56·5
Pure bitumen soluble in 88° naphtha	63·1
Pure bitumen as saturated hydrocarbons	24·4
Sulphur	6·2
Residual coke, ash free	10·8

VENEZUELA.

"Bermudez."

Penetration	26·0
Bitumen soluble in CS_2	96·0
Pure bitumen soluble in 88° naphtha	71·9
Pure bitumen as saturated hydrocarbons	23·4
Sulphur	4·7
Residual coke, ash free	14·0

Maracaibo.

Penetration	20·0
Bitumen soluble in CS_2	96·8
Pure bitumen soluble in 88° naphtha	47·2
Pure bitumen as saturated hydrocarbons	25·3
Sulphur	5·7
Residual coke, ash free	18·0

Clifford Richardson.

"Residual pitch" from the distillation of various oils is also used instead of native asphalt, but such products in general contain much less sulphur than the natural material, and are proportionately softer, as is shown by the penetration figures.

In addition to "residual pitches," bitumens are also sold in the United States for use in paving, prepared from petroleum residues by treatment with sulphur or air at high temperatures. These are known as condensed or blown oils.

PARTICULARS OF RESIDUAL PITCHES.

Source.	Penetration.	Ductility.	Bitumen soluble in CS_2.	Pure Bitumen soluble in 88° Naphtha.	Pure Bitumen as saturated Hydrocarbons.	Paraffin Scale.	Sulphur.	Residual Coke, Ash Free.
California, Kern River.	165	110	99·7	76·8	26·3	Trace.	1·2	10·4
California, Kern River.	31	130	99·6	81·9	30·0	Trace.	1·3	12·9
California, Los Angeles.	43	130	99·5	84·0	31·1	0·6	0·82	..
California, S. O. Co.	72	133	99·0	89·0	32·1	0·5	1·17	9·2
Mexico, Ebano	42	..	99·4	60·7	31·7	1·0	5·90	19·2
,, ,,	5	..	95·8	47·4	32·2	1·9	6·89	30·5
Texas . .	110	Brittle.	96·6	73·6	58·1	1·0	0·62	17·6
,, . .	18	Brittle.	98·2	70·9	65·6	0·8	..	19·5
Trinidad .	45	135	99·0	70·8	24·6	Trace.	1·93	..

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PARTICULARS OF CONDENSED OR BLOWN OILS.

Description.	Penetration.	Ductility.	Bitumen soluble in CS_2.	Per cent. Pure Bitumen soluble in 88° Naphtha.	Per cent. Pure Bitumen as saturated Hydrocarbons.	Paraffin Scale.	Sulphur.	Residual Coke, Ash Free.
Pittsburgh Flux.	38	None.	97·6	66·1	55·5	3·7	4·75	13·7
Hydroline "B"	55	None.	99·9	67·9	64·2	1·0	0·56	12·2
California Obispo, 1909.	25	$7\frac{3}{4}$ cm.	99·6	61·5	35·7	0·1	1·22	17·3
S. O. Co. Binder No. 3.	85	$3\frac{1}{2}$ cm.	98·8	74·9	44·3	1·0	0·77	13·2
S. O. Co. Binder "B."	135	29 cm.	99·8	76·1	51·7	3·1	0·68	12·6
Gulf Binder .	35	6 cm.	99·4	70·1	48·4	0·2	0·71	14·6

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PARTICULARS OF FLUXES.

Source.	Sp. Gr.	Per cent. Pure Bitumen soluble in 88° Naphtha.	Per cent. Pure Bitumen as saturated Hydro-carbons.	Paraffin Scale.	Sul-phur.	Residual Coke, Ash Free.
California . .	1·002	92·4	47·9	..	..	6·0
California, "G" grade	1·006	92·3	41·8	..	..	6·0
Canada . .	0·937	96·9	78·0	8·1	..	..
France (shale oil) .	0·985	93·6	43·6	4·4	Trace.	3·0
Indiana . .	0·930	96·6	75·3	7·9	0·50	1·9
Kansas . .	0·926	97·4	74·1	8·9	0·61	1·8
Kentucky . .	0·940	96·5	85·0	10·3	..	..
Mexico . .	1·007	79·9	43·2	2·0	4·3	10·0
Ohio . .	0·924	..	81·9	8·5	2·6	4·0
,, . .	0·922	99·4	78·3	9·6	..	..
Pennsylvania .	0·913	..	85·6	14·5	0·6	..
Russia . .	0·910	..	79·3	..	..	..
Texas, Corsicana .	0·940	95·6	83·1	4·0	..	..
,, Beaumont .	0·974	95·2	79·4	1·7	..	3·5
,, ,, .	0·952	99·1	72·3	1·0	..	..
Trinidad . .	1·004	86·9	35·3	..	2·6	7·0

Clifford Richardson.

19

MEDICINAL USES.

The following substances, products of petroleum, are included in the British Pharmaceutical Codex :—

Pharmaceutical Name.	Common Name.	Specific Gravity.	Use.
Benzinum . .	Benzine.	0·640–0·670	In certain skin affections.
Ligroïnum . .	Ligroïn.	0·707–0·722	As solvent for fats.
Paraffinum album .	White paraffin.	. .	In ointments.
Paraffinum carbolisatum.	Carbolised paraffin.	. .	Antiseptic application for wounds and lubricant for instruments.
Paraffinum durum .	Paraffin wax.	. .	In ointments and plastic operations.
Paraffinum liquidum .	Decolorised petroleum	0·885–0·890	As a vehicle for oily spray solutions, etc., and internally for gastric derangements, etc.
Paraffinum molle .	Vaseline.	0·840–0·870	For ointments, etc.

PART VII.

WEIGHTS AND MEASURES.

WEIGHTS AND MEASURES.

THE weights and measures employed in the oil industry, including those in use in countries in which oil is produced, or is likely to be obtained in the near future, are given in the following tables. In several foreign countries which have adopted the metric system as the legal standard, several old systems of weights and measures are still in use, and as far as possible these have been given. These ancient weights and measures will be found useful, as they frequently occur in early reports and statistical data.

MEASURES OF TIME.

60 thirds	=1 second.
60 secs.	=1 minute.
60 mins.	=1 hour.
23 hrs. 56 mins. 4·099 secs. .	=1 sidereal day.
24 hrs.	=1 day.
7 days	=1 week.
28 days	=1 lunar month.
28, 29, 30, or 31 days . .	=1 calendar month.
12 calendar months . . .	=1 year.
365 days	=1 common year.
365 days 5 hrs. 48 mins. 46 secs.	=1 tropical year.
365 days 6 hrs. 9 mins. 9·3 secs.	=1 sidereal year.
366 days	=1 leap year.*

* Also called bissextile from having, in Roman notation, an extra day at February 24th, the sixth before the kalends of March. This is still kept in ecclesiastical calendars on the Continent, but was placed as February 29th in Great Britain in 1662.

Thirty days have September,
April, June, and November;
In February twenty-eight alone;
In all the rest are thirty-one;
Three sixty-five a year there are;
Three sixty-six in each leap year,
When twenty-nine in February come,
As settled by the seers of ancient Rome.

AVOIRDUPOIS WEIGHT.

16 drams or 437·5 grains	=1 ounce.
16 ounces or 7000 grains	=1 lb.
14 lbs.	=1 stone.
28 lbs.	=1 quarter.
4 qrs. or 112 lbs. . .	=1 cwt.
20 cwts. or 2240 lbs. .	=1 ton.

TROY WEIGHT.

24 grains . .	=1 pennyweight.
20 pennyweights	=1 ounce.
12 ounces . .	=1 pound.

Note.—Used for precious metals.

ANGULAR MEASURE.

60 seconds (″) . . .	=1 minute.
60 minutes (′) . . .	=1 degree.
11·25 degrees (°) . . .	=1 point (of compass).
30°	=1 sign.
90°	=1 quadrant.
4 quadrants, or 360° . .	=1 circumference.

Degree of equator . . .	=69·161 miles.
Degree of meridian . . .	=69·046 ,, (average); 68·072 at equator, 69·396 at poles.

DIFFERENCE IN TIME IN RELATION TO LONGITUDE.

15″	=1 second.
1′	=4 seconds.
1°	=4 minutes.

MEASURES OF LENGTH.

12 inches	=1 foot.
3 feet	=1 yard.
7·92 inches	=1 link.
$5\frac{1}{2}$ yards or 25 links . . .	=1 rod, pole, or perch.
100 links, 4 rods, or 66 feet . .	=1 chain.
220 yards, 40 rods, or 10 chains .	=1 furlong.
8 furlongs, 1760 yards, or 5280 feet	=1 statute mile.
3 miles	=1 league.

NAUTICAL MEASURES OF LENGTH.

6 feet	=1 fathom.
$12\frac{1}{2}$ fathoms . . .	=1 shackle or length of cable
8 shackles or 100 fathoms	=1 cable's length.
6080 feet . . .	=1 nautical mile.
1 knot	=1 nautical mile in 1 hour.

SQUARE MEASURE.

144 square inches . .	=1 square foot.
9 square feet . . .	=1 square yard.
$30\frac{1}{4}$ square yards . .	=1 square pole, rod, or perch
40 square poles . . .	=1 rood.
4 roods or 4840 square yards	=1 acre.
640 acres	=1 square mile.

CUBIC MEASURE.

1728 cubic inches	=1 cubic foot.
27 cubic feet	=1 cubic yard.

MEASURES OF CAPACITY.

2 pints . . .	= 1 quart.
4 quarts . . .	= 1 gallon.
1 barrel of oil (crude) .	= 35 Imperial gallons or 42 U.S.A. gallons.
1 barrel of oil (refined or other product) .	= 41·66 Imperial gallons or 50 U.S.A. gallons.
1 Imperial gallon .	= ·833 U.S.A. gallon.

DRY MEASURE.

2 pints	= 1 quart.
4 quarts	= 1 gallon.
2 gallons	= 1 peck.
4 pecks	= 1 bushel.
8 bushels	= 1 quarter.
5 quarters	= 1 wey or horse-load.
10 quarters	= 1 last.

PAPER MEASURE.

24 sheets	= 1 quire.
20 quires	= 1 ream.
516 sheets	= 1 printer's ream.
2 reams	= 1 bundle.
10 reams	= 1 bale.

SIZES OF DRAWING PAPER.

Demy	$20 \times 15\frac{1}{2}$ inches.
Imperial	30×22 ,,
Double elephant . . .	40×27 ,,
Antiquarian	52×31 ,,
Emperor	72×48 ,,

METRIC WEIGHTS AND MEASURES AND THEIR ENGLISH EQUIVALENTS.

LINEAR MEASURE.

	Metres.	Inches.	Feet.	Yards.	Miles.
Millimetre .	·001	·03937	·00328	·00109	..
Centimetre .	·01	·3937	·0328	·0109	..
Decimetre .	·1	3·937	·328	·1093	·00006
Metre * .	1	39·37079	3·2809	1·09363	·00062
Decametre .	10	..	32·809	10·936	·0062
Hectometre .	100	..	328·09	109·36	·06214
Kilometre .	1,000	..	3280·9	1093·6	·62138
Myriametre .	10,000	..	..	..	6·21382

* 1 metre=1·093633056 yard.

SQUARE MEASURE.

	Square Metres.	Square Inches.	Square Feet.	Square Yards.	Acres.
Milliare .	·1	155	1·076	·119	..
Centiare * .	1	1,550	10·764	1·19	·00025
Deciare .	10	15,501	107·64	11·96	·0025
Are . .	100	..	1076·4	119·6	·0247
Decare .	1,000	..	..	1,196	·2471
Hectare .	10,000	..	..	11,960	2·4711

* Or 1 square metre=1·196033292 square yard.

SOLID MEASURE.

	Cubic Metre.	Cubic Inches.	Cubic Feet.	Cubic Yards.
Millistere . .	·001	61·028	..	..
Centistere . .	·01	610·28	·353	..
Decistere . .	·1	6,102·8	3·5317	·1308
Stere, or cubic metre	1	61,028	35·317	1·308
Decastere . .	10	..	..	13·08
Hectostere . .	100	..	..	130·802

METRIC WEIGHTS AND MEASURES AND THEIR ENGLISH EQUIVALENTS—*continued.*

WEIGHTS.

	Grammes.	Avoirdupois Ounces.	Avoirdupois Pounds.	Cwts.	Tons.	Grains Troy.
Milligramme	·001	..	..	..	..	·015
Centigramme	·01	..	..	..	..	·154
Decigramme	·1	..	..	..	..	1·543
Gramme .	1	·035	·0022	..	..	15·432349
Decagramme	10	·35	·022	..	..	..
Hectogramme.	100	3·527	·22046	..	..	.. Oz. Troy.
Kilogramme	1,000	35·2739	2·2046	·019	·00098	32·15
Myriagramme.	10,000	..	22·04	·1968	·00984	..
Quintal .	100,000	..	220·46	1·9684	·0984	..
Millier or Bar.	1,000,000	..	2204·62	19·684	·984206	..

DRY AND FLUID MEASURE.

	Litres.	Inches.	Feet.	Gallons.	Bushels.
Millilitre .	·001	·061	..	·00022	..
Centilitre .	·01	·61	..	·0022	..
Decilitre .	·1	6·1	..	·022	·0027
Litre * .	1	61·02	·0353	·22	·0275
Decalitre .	10	610·28	·353	2·2	·275
Hectolitre .	100	..	3·53	22	2·751
Kilolitre † .	1,000	..	35·317	220	27·512
Myrialitre .	10,000	..	353·17	2200·967	275·121

* Litre = ·22009668 gallon = a cubic decimetre.
† Kilolitre = a cubic metre.

Molesworth's Metrical Tables.

EQUIVALENTS OF KILOMETRES IN MILES.

Kilometres.	Miles.	Kilometres.	Miles.	Kilometres.	Miles.
1	·6214	35	21·7490	68	42·2552
2	1·2428	36	22·3704	69	42·8766
3	1·8642	37	22·9918	70	43·4980
4	2·4856	38	23·6132	71	44·1194
5	3·1070	39	24·2346	72	44·7408
6	3·7284	40	24·8560	73	45·3622
7	4·3498	41	25·4774	74	45·9836
8	4·9712	42	26·0988	75	46·6050
9	5·5926	43	26·7202	76	47·2264
10	6·2140	44	27·3416	77	47·8478
11	6·8354	45	27·9630	78	48·4692
12	7·4568	46	28·5844	79	49·0906
13	8·0782	47	29·2058	80	49·7120
14	8·6996	48	29·8272	81	50·3334
15	9·3210	49	30·4486	82	50·9548
16	9·9424	50	31·0700	83	51·5762
17	10·5638	51	31·6914	84	52·1976
18	11·1852	52	32·3128	85	52·8190
19	11·8066	53	32·9342	86	53·4404
20	12·4280	54	33·5556	87	54·0618
21	13·0494	55	34·1770	88	54·6832
22	13·6708	56	34·7984	89	55·3046
23	14·2922	57	35·4198	90	55·9260
24	14·9136	58	36·0412	91	56·5474
25	15·5350	59	36·6626	92	57·1688
26	16·1564	60	37·2840	93	57·7902
27	16·7778	61	37·9054	94	58·4116
28	17·3992	62	38·5268	95	59·0330
29	18·0206	63	39·1482	96	59·6544
30	18·6420	64	39·7696	97	60·2758
31	19·2634	65	40·3910	98	60·8972
32	19·8848	66	41·0124	99	61·5186
33	20·5062	67	41·6338	100	62·1400
34	21·1276				

EQUIVALENTS OF KILOGRAMS IN POUNDS.

Kilograms.	Pounds.	Kilograms.	Pounds.	Kilograms.	Pounds.
1	2·2046	38	83·7748	75	165·3450
2	4·4092	39	85·9794	76	167·5496
3	6·6138	40	88·1840	77	169·7542
4	8·8184	41	90·3886	78	171·9588
5	11·0230	42	92·5932	79	174·1634
6	13·2276	43	94·7978	80	176·3680
7	15·4322	44	97·0024	81	178·5726
8	17·6368	45	99·2070	82	180·7772
9	19·8414	46	101·4116	83	182·9818
10	22·0460	47	103·6162	84	185·1864
11	24·2506	48	105·8208	85	187·3910
12	26·4552	49	108·0254	86	189·5956
13	28·6598	50	110·2300	87	191·8002
14	30·8644	51	112·4346	88	194·0048
15	33·0690	52	114·6392	89	196·2094
16	35·2736	53	116·8438	90	198·4140
17	37·4782	54	119·0484	91	200·6186
18	39·6828	55	121·2530	92	202·8232
19	41·8874	56	123·4576	93	205·0278
20	44·0920	57	125·6622	94	207·2324
21	46·2966	58	127·8668	95	209·4370
22	48·5012	59	130·0714	96	211·6416
23	50·7058	60	132·2760	97	213·8462
24	52·9104	61	134·4806	98	216·0508
25	55·1150	62	136·6852	99	218·2554
26	57·3196	63	138·8898	100	220·4600
27	59·5242	64	141·0944	200	440·9200
28	61·7288	65	143·2990	300	661·3800
29	63·9334	66	145·5036	400	881·8400
30	66·1380	67	147·7082	500	1102·3000
31	68·3426	68	149·9128	600	1322·7600
32	70·5472	69	152·1174	700	1543·2200
33	72·7518	70	154·3220	800	1763·6800
34	74·9564	71	156·5266	900	1984·1400
35	77·1610	72	158·7312	1000	2204·6000
36	79·3656	73	160·9358	1016·05733	1 ton
37	81·5702	74	163·1404		

EQUIVALENTS OF HECTARES IN ACRES.

Hectares.	Acres.	Hectares.	Acres.	Hectares.	Acres.
1	2·471	35	86·485	68	168·028
2	4·942	36	88·956	69	170·499
3	7·413	37	91·427	70	172·970
4	9·884	38	93·898	71	175·441
5	12·355	39	96·369	72	177·912
6	14·826	40	98·840	73	180·383
7	17·297	41	101·311	74	182·854
8	19·768	42	103·782	75	185·325
9	22·239	43	106·253	76	187·796
10	24·710	44	108·724	77	190·267
11	27·181	45	111·195	78	192·738
12	29·652	46	113·666	79	195·209
13	32·123	47	116·137	80	197·680
14	34·594	48	118·608	81	200·151
15	37·065	49	121·079	82	202·622
16	39·536	50	123·550	83	205·093
17	42·007	51	126·021	84	207·564
18	44·478	52	128·492	85	210·035
19	46·949	53	130·963	86	212·506
20	49·420	54	133·434	87	214·977
21	51·891	55	135·905	88	217·448
22	54·362	56	138·376	89	219·919
23	56·833	57	140·847	90	222·390
24	59·304	58	143·318	91	224·861
25	61·775	59	145·789	92	227·332
26	64·246	60	148·260	93	229·803
27	66·717	61	150·731	94	232·274
28	69·188	62	153·202	95	234·745
29	71·659	63	155·673	96	237·216
30	74·130	64	158·144	97	239·687
31	76·601	65	160·615	98	242·158
32	79·072	66	163·086	99	244·629
33	81·543	67	165·557	100	247·100
34	84·014				

ARGENTINE REPUBLIC.

The metric system has been adopted, and the system was made obligatory in 1887.

Arroba	= 25·318253 lbs.
Quintal	= 101·27314 ,,
Tonelada	= 0·904 ton.

AUSTRIA.

Comparison of Austrian Old and New Surface, or Square, Measures and their British Imperial Value.

		British Imperial Value.
1 square metre	= 0·278036 square klafter	= 10·7643 square feet.
1 ,, ,,	= 10·01931 square fuss	= 1·195992 square yards.
1 ar.	= 27·80364 square klafter	= 3·9536 poles.
1 hektar	= 1·737727 joch	= 2·47105 acres.
1 square myriametre	= 1·737727 square mile	= 24710·58 acres.
1 square klafter	= 3·596652 square metres	= 4·30171 square yards.
1 square fuss	= 0·099907 square metre	= 1·075428 square foot.
1 joch	= 57·54642 ar.	= 1·421972 acres.
1 ,,	= 0·5754642 hektar	
1 mile	= 0·5754642 square myriametre	= 14219·72 acres.

Cubic Measures.

		British Imperial Value.
1 kubik metre	= 0·146606 kubik klafter	=35·314758 cubic feet.
1 ,, ,,	=31·66695 kubik fuss	= 1·307954 cubic yards.
1 ,, klafter	= 6·820992 kubik metres	=240·88168 cubic feet.
1 ,, fuss	= 0·03157867 kubik metres	=1·11519 cubic feet.

BOLIVIA.

The legal weights and measures in use are those of the metric system. Some of the old weights and measures were :—

Libra . . .	= 1·04 lbs.
Quintal . . .	=101·44 ,,
Arroba (of weight) .	= 25·36 ,,
Arroba (of wines, etc.) .	= 6·70 gallons.
Gallon . . .	= 0·74 gallon.
Vara . . .	= 0·927 yard.
Square vara . .	= 0·859 square yard.

BRAZIL.

Libra . . .	= 1·012 lbs. av.
Arroba . . .	= 32·38 ,, ,,
Quintal . . .	=129·54 ,, ,,

BURMA.

1 taung (cubit) . .	=22 inches.
1 viss=100 tikals . .	$=3\frac{1}{2}$ lbs.
1 daing . . .	=2 miles.
1 Indian or imperial maund	=82·28 lbs.
1 maund of 40 seers .	=9·8098 imperial gallons.

DUTCH EAST INDIES.

The legal weights and measures generally used in the Dutch East Indies are those of the Netherlands.

The metric system is in use in Java.

EGYPT.

The metric system is in use. Some of the old weights and measures are as follows :—

Pike draâ or diraâ of 4 rubs, each of 6 kirats . . .	= 27 inches.
Gasab of 4 diraâs . .	= 3 yards.
Feddan = 400 square gasab .	= 1·1265779 acres.
Cantar of 100 rottolos . .	= 98·048138 lbs.

FRANCE.

Arpent.

Old French Measure of Land.

The "arpent" was the chief land measure; it varied in different localities; it usually contained 100 perches, but the Normandy "arpent" was 160 perches, and the perche varied from 18 to 22 square pieds. The "arpent" consequently varied from something under an acre to a little over 2 acres British statute measure.—*Browne.*

HOLLAND.

The metric system is in use. Dutch names have been applied to the metric denominations, and it is optional to use either.

1 pond (kilogram)	=	2·2046 lbs.
1 bunder (hectare)	=	2·471 acres.
1 mijl (kilometre)	=	1093·6143 yards or ·62137 mile.

JAPAN.

10 tan	=1 choo	= 2·4506 acres.
10 go	=1 shoö	= 1·5872 imperial quarts.
10 shoö	=1 to	= 3·9681 imperial galls.
10 to	=1 koko	=39·6814 " "
160 momme	=1 kin	=nearly 1·33 lbs.
100 kin	=1 hiyak-kin	=132·5073 lbs.

MEXICO.

The metric system is used, but some of the old Spanish weights are still employed.

Libra . .	= 1·014 lbs.
Arroba (25 libras) .	= 25·357 lbs.
Quintal or 100 libras	=101·4439 lbs.
Vara . .	= 2 feet, 8·9 inches
Legua comun .	= 6,666 varas, 3·4617 miles, 5556 metres.

PERU.

The legal weights and measures are those of the metric system. Some old ones, however, are still occasionally employed, such as:—

Libra .	= 1·014 lbs. av.
Quintal .	=101·44 " "
Arroba .	= 25·36 " "
Gallon .	= 0·74 gallon.
Vara .	= 0·927 yard.
Square vara	= 0·859 square yard.

RUMANIA.

The weights and measures are those of the metric system. Some old ones, however, are still used.

8 palme	=1 stingin.
1 stingin	=2 metres.
1 pogon	=·5 hectare or 1·235 acre.

RUSSIAN MEASURES.

Weight.

96 dolia	=1 zolotnik.
3 zolotnik	=1 lot.
32 lot	=1 phunt (pound).
40 phunts	=1 pood.
10 poods	=1 berkovets.

Linear.

10 scrupules	=1 linia.
10 linia	=1 dium (inch).
12 dium	=1 phut (foot).
$1\frac{3}{4}$ dium	=1 verschok.
28 dium or 16 verschok	=1 arschin.
7 phut or 3 arschin	=1 sajen.
500 sajen	=1 verst.

Square Measure.

144 square dium	=1 square phut.
256 square verschok	=1 square arschin.
9 square arschin or 49 square phut	=1 square sajen.
2400 square sajen	=1 desiatine.

Cubic Measure.

1728 cubic dium	=1 cubic phut.
4096 cubic verschok	=1 cubic arschin.
343 cubic phut	=1 cubic sajen.

Capacity (Liquids).

10 tcharka	=1 krujka.
10 krujka	=1 vedro, or 2·7069 gallons.

EQUIVALENTS OF POODS IN TONS.

Poods.	Tons.	Poods.	Tons.	Poods.	Tons.
1	·01612	35	·56420	68	1·09616
2	·03224	36	·58032	69	1·11228
3	·04836	37	·59644	70	1·12840
4	·06448	38	·61256	71	1·14452
5	·08060	39	·62868	72	1·16064
6	·09672	40	·64480	73	1·17676
7	·11284	41	·66092	74	1·19288
8	·12896	42	·67704	75	1·20900
9	·14508	43	·69316	76	1·22512
10	·16120	44	·70928	77	1·24124
11	·17732	45	·72540	78	1·25736
12	·19344	46	·74152	79	1·27348
13	·20956	47	·75764	80	1·28960
14	·22568	48	·77376	81	1·30572
15	·24180	49	·78988	82	1·32184
16	·25792	50	·80600	83	1·33796
17	·27404	51	·82212	84	1·35408
18	·29016	52	·83824	85	1·37020
19	·30628	53	·85436	86	1·38632
20	·32240	54	·87048	87	1·40244
21	·33852	55	·88660	88	1·41856
22	·35464	56	·90272	89	1·43468
23	·37076	57	·91884	90	1·45080
24	·38688	58	·93496	91	1·46692
25	·40300	59	·95108	92	1·48304
26	·41912	60	·96720	93	1·49916
27	·43524	61	·98332	94	1·51528
28	·45136	62	·99944	95	1·53140
29	·46748	63	1·01556	96	1·54752
30	·48360	64	1·03168	97	1·56364
31	·49972	65	1·04780	98	1·57976
32	·51584	66	1·06392	99	1·59588
33	·53196	67	1·08004	100	1·61200
34	·54808				

EQUIVALENTS OF DESIATINES IN ACRES.

Desiatines.	Acres.	Desiatines.	Acres.	Desiatines.	Acres.
1	2·7	35	94·5	68	183·6
2	5·4	36	97·2	69	186·3
3	8·1	37	99·9	70	189·0
4	10·8	38	102·6	71	191·7
5	13·5	39	105·3	72	194·4
6	16·2	40	108·0	73	197·1
7	18·9	41	110·7	74	199·8
8	21·6	42	113·4	75	202·5
9	24·3	43	116·1	76	205·2
10	27·0	44	118·8	77	207·9
11	29·7	45	121·5	78	210·6
12	32·4	46	124·2	79	213·3
13	35·1	47	126·9	80	216·0
14	37·8	48	129·6	81	218·7
15	40·5	49	132·3	82	221·4
16	43·2	50	135·0	83	224·1
17	45·9	51	137·7	84	226·8
18	48·6	52	140·4	85	229·5
19	51·3	53	143·1	86	232·2
20	54·0	54	145·8	87	234·9
21	56·7	55	148·5	88	237·6
22	59·4	56	151·2	89	240·3
23	62·1	57	153·9	90	243·0
24	64·8	58	156·6	91	245·7
25	67·5	59	159·3	92	248·4
26	70·2	60	162·0	93	251·1
27	72·9	61	164·7	94	253·8
28	75·6	62	167·4	95	256·5
29	78·3	63	170·1	96	259·2
30	81·0	64	172·8	97	261·9
31	83·7	65	175·5	98	264·6
32	86·4	66	178·2	99	267·3
33	89·1	67	180·9	100	270·0
34	91·8				

EQUIVALENTS OF VERSTS IN MILES.

Versts.	Miles.	Versts.	Miles.	Versts.	Miles.
1	·663	35	23·205	68	45·084
2	1·326	36	23·868	69	45·747
3	1·989	37	24·531	70	46·410
4	2·652	38	25·194	71	47·073
5	3·315	39	25·857	72	47·736
6	3·978	40	26·520	73	48·399
7	4·641	41	27·183	74	49·062
8	5·304	42	27·846	75	49·725
9	5·967	43	28·509	76	50·388
10	6·630	44	29·172	77	51·051
11	7·293	45	29·835	78	51·714
12	7·956	46	30·498	79	52·377
13	8·619	47	31·161	80	53·040
14	9·282	48	31·824	81	53·703
15	9·945	49	32·487	82	54·366
16	10·608	50	33·150	83	55·029
17	11·271	51	33·813	84	55·692
18	11·934	52	34·476	85	56·355
19	12·597	53	35·139	86	57·018
20	13·260	54	35·802	87	57·681
21	13·923	55	36·465	88	58·344
22	14·586	56	37·128	89	59·007
23	15·249	57	37·791	90	59·670
24	15·912	58	38·454	91	60·333
25	16·575	59	39·117	92	60·996
26	17·238	60	39·780	93	61·659
27	17·901	61	40·443	94	62·322
28	18·564	62	41·106	95	62·985
29	19·227	63	41·769	96	63·648
30	19·890	64	42·432	97	64·311
31	20·553	65	43·095	98	64·974
32	21·216	66	43·758	99	65·637
33	21·879	67	44·421	100	66·300
34	22·542				

UNITED STATES.

1 gallon = ·833111 imperial gallons.
1 ton = 2000 lbs.

VENEZUELA.

The weights and measures in legal use are those of the metric system, but the following are occasionally employed:—

Libra = 1·014 lbs. av.
Quintal = 101·4 lbs. av.
Arroba = 25·35 lbs. av.
Legua = 5556 metres.

TABLE FOR CONVERTING QUANTITIES OF PETROLEUM GIVEN IN METRIC TONS INTO IMPERIAL GALLONS.

If the specific gravity of the oil is

0·700 × 314·946042	0·780 × 282·643884
0·705 × 312·712382	0·785 × 280·843605
0·710 × 310·510183	0·790 × 279·066113
0·715 × 308·338783	0·795 × 277·310981
0·720 × 306·197541	0·800 × 275·577787
0·725 × 304·085834	0·805 × 273·866124
0·730 × 302·003054	0·810 × 272·175555
0·735 × 299·948612	0·815 × 270·505803
0·740 × 297·921932	0·820 × 268·856378
0·745 × 295·922456	0·825 × 267·226945
0·750 × 292·616306	0·830 × 265·617144
0·755 × 292·002953	0·835 × 264·026622
0·760 × 290·081881	0·840 × 262·455035
0·765 × 288·185921	0·845 × 260·902047
0·770 × 286·314584	0·850 × 259·367329
0·775 × 284·467393	0·855 × 257·850561

0·860 × 256·351430	0·895 × 246·326513
0·865 × 254·869630	0·900 × 244·958038
0·870 × 253·404862	0·910 × 242·266186
0·875 × 251·956834	0·915 × 240·942327
0·880 × 250·525261	0·950 × 232·065505
0·885 × 249·109864	1·000 × 220·46223
0·890 × 247·710370	

Note.—To convert imperial gallons into metric tons, divide the number of imperial gallons by the figures given in the second column.

In the above table the metric ton has been taken as being equivalent to 2204·6223 lbs. av.

[TABLE.

DECIMAL EQUIVALENTS OF THE SIXTY-FOURTHS OF AN INCH.

Fraction of an Inch.	Decimal of an Inch.	Fraction of an Inch.	Decimal of an Inch.
$\frac{1}{64}$	0·015625	$\frac{33}{64}$	0·515625
$\frac{1}{32}$	0·031250	$\frac{17}{32}$	0·531250
$\frac{3}{64}$	0·046875	$\frac{35}{64}$	0·546875
$\frac{1}{16}$	0·062500	$\frac{9}{16}$	0·562500
$\frac{5}{64}$	0·078125	$\frac{37}{64}$	0·578125
$\frac{3}{32}$	0·093750	$\frac{19}{32}$	0·593750
$\frac{7}{64}$	0·109375	$\frac{39}{64}$	0·609375
$\frac{1}{8}$	0·125000	$\frac{5}{8}$	0·625000
$\frac{9}{64}$	0·140625	$\frac{41}{64}$	0·640625
$\frac{5}{32}$	0·156250	$\frac{21}{32}$	0·656250
$\frac{11}{64}$	0·171875	$\frac{43}{64}$	0·671875
$\frac{3}{16}$	0·187500	$\frac{11}{16}$	0·687500
$\frac{13}{64}$	0·203125	$\frac{45}{64}$	0·703125
$\frac{7}{32}$	0·218750	$\frac{23}{32}$	0·718750
$\frac{15}{64}$	0·234375	$\frac{47}{64}$	0·734375
$\frac{1}{4}$	0·250000	$\frac{3}{4}$	0·750000
$\frac{17}{64}$	0·265625	$\frac{49}{64}$	0·765625
$\frac{9}{32}$	0·281250	$\frac{25}{32}$	0·781250
$\frac{19}{64}$	0·296875	$\frac{51}{64}$	0·796875
$\frac{5}{16}$	0·312500	$\frac{13}{16}$	0·812500
$\frac{21}{64}$	0·328125	$\frac{53}{64}$	0·828125
$\frac{11}{32}$	0·343750	$\frac{27}{32}$	0·843750
$\frac{23}{64}$	0·359375	$\frac{55}{64}$	0·859375
$\frac{3}{8}$	0·375000	$\frac{7}{8}$	0·875000
$\frac{25}{64}$	0·390625	$\frac{57}{64}$	0·890625
$\frac{13}{32}$	0·406250	$\frac{29}{32}$	0·906250
$\frac{27}{64}$	0·421875	$\frac{59}{64}$	0·921875
$\frac{7}{16}$	0·437500	$\frac{15}{16}$	0·937500
$\frac{29}{64}$	0·453125	$\frac{61}{64}$	0 953125
$\frac{15}{32}$	0·468750	$\frac{31}{32}$	0·968750
$\frac{31}{64}$	0·484375	$\frac{63}{64}$	0·984375
$\frac{1}{2}$	0·500000	1	1·000000

MEASURES OF TIMBER.

1 square . . .	=100 superficial feet.
120 deals . . .	=1 hundred.
40 cubic feet unhewn timber	=1 load.
50 cubic feet squared timber	=1 load.
600 superficial feet of 1 inch planks or deals . .	=1 load.
Battens are 7 inches wide.	
Deals are 9 inches wide.	
Planks are 11 inches wide.	
A St. Petersburg standard .	=165 cubic feet (120 deals $6' \times 11'' \times 3''$).
A London standard .	=270 cubic feet (120 deals $12' \times 9'' \times 3''$).
A cord of wood . .	$=4' \times 4' \times 8'$ or 128 cubic feet.

The following will weigh, on the average, one ton :—

66	cubic	feet of	deals.
64	,,	,,	fir timber.
57	,,	,,	elm timber.
51	,,	,,	beech.
29	,,	,,	ebony.
59	,,	,,	lime.
45	,,	,,	ash.
39	,,	,,	oak.
34	,,	,,	mahogany
53	,,	,,	walnut.
48	,,	,,	maple.
60	,,	,,	pine.

A log or stick of timber is the trunk of a tree after lopping off the branches.

A balk of timber is obtained by roughly squaring a log.

CONVERSION TABLES.

Reciprocals for converting—	*Multiply by—*
Acres to hectares	0·404671
Acres to square metres	0·0002471
Acres to square miles	0·0015625
Acres to square yards	4840·0
Atmospheres to lbs. per square inch	14·7
British thermal units per lb. to calories per gram	0·555
Calories per gram to British thermal units per lb.	1·8
Centimetres to inches	0·3937
Circumference to diameter	0·31831
Cubic centimetres to cubic inches	0·061028
Cubic feet to cubic metres	0·028315
Cubic inches to cubic centimetres	16·386
Cubic inches to litres	0·016386
Cubic metres to cubic feet	35·31476
Cubic metres to cubic yards	1·307954
Cubic yards to cubic metres	0·7645131
Desiatines to acres	2·7
Diameter to circumference	3·1416
Feet to metres	0·3047945
Gallons to litres	4·543457
Grains to grams	0·064799
Grams to grains	15·432349
Grams to ounces av.	0·0353
Grams to lbs.	0·0022
Hectares to acres	2·471143
Horse-power to kilowatts	0·7461
Inches to centimetres	2·53995
Inches to millimetres	25·39954
Kilograms to lbs. av.	2·20462
Kilograms to tons	0·000984

Kilograms per square centimetre to lbs. per square inch	14·2233
Kilograms per square metre to lbs. per square foot	0·20482
Kilometres to miles	0·62138
Kilowatts to horse-power	1·3404
Koku to imperial gallons	39·7
Litres to cubic inches	61·02
Litres to gallons	0·22
Litres to pints	1·7598
Metres to feet	3·2808992
Metres to yards	1·093633
Metric tons to lbs. av.	2204·6223
Miles to kilometres	1·6093149
Miles to versts	1·50829
Millimetres to inches	0·03937
Otvods to acres	27·0
Ounces to grams	28·349375
Pints to litres	0·567
Poods to lbs. av.	36·1141
Poods to metric tons	0·016378
Poods to tons	0·01612
Lbs. to grams	453·59
Lbs. av. to kilograms	0·45359265
Lbs. per square inch to atmospheres	0·06803
Lbs. per square inch to kilograms per square centimetre	0·07031
Lbs. per square foot to kilograms per square metre	4·8824
Russian mining claim (Zaiavka) to acres	101·25
Square centimetre to square inches	0·1550591
Square feet to square metres	0·092899
Square inches to square centimetres	6·4516
Square kilometres to square miles	0·3861
Square miles to square kilometres	2·5898945

CONVERSION TABLES—*continued.*

Reciprocals for converting—	*Multiply by—*
Square metres to square feet .	10·7643
Square metres to square yards .	1·196033292
Square yards to square metres .	0·8361
Square yards to square miles .	0·000000323
Tons to kilograms . .	1016·048
Versts to miles . . .	0·663
Yards to metres . . .	0·91438384

Zaiavka. *See* Russian mining claim.

CONVERSION OF POUNDS PER SQUARE INCH INTO KILOS PER SQUARE CENTIMETRE.

Lbs. per Sq. Inch.	Kilos per Sq. Centimetre.	Lbs. per Sq. Inch.	Kilos per Sq. Centimetre.	Lbs. per Sq. Inch.	Kilos per Sq. Centimetre.
1	0·0703	35	2·4605	68	4·7804
2	0·1406	36	2·5308	69	4·8507
3	0·2109	37	2·6011	70	4·9210
4	0·2812	38	2·6714	71	4·9913
5	0·3515	39	2·7417	72	5·0616
6	0·4218	40	2·8120	73	5·1319
7	0·4921	41	2·8823	74	5·2022
8	0·5624	42	2·9526	75	5·2725
9	0·6327	43	3·0229	76	5·3428
10	0·7030	44	3·0932	77	5·4131
11	0·7733	45	3·1635	78	5·4834
12	0·8436	46	3·2338	79	5·5537
13	0·9139	47	3·3041	80	5·6240
14	0·9842	48	3·3744	81	5·6943
15	1·0545	49	3·4447	82	5·7646
16	1·1248	50	3·5150	83	5·8349
17	1·1951	51	3·5853	84	5·9052
18	1·2654	52	3·6556	85	5·9755
19	1·3357	53	3·7259	86	6·0458
20	1·4060	54	3·7962	87	6·1161
21	1·4763	55	3·8665	88	6·1864
22	1·5466	56	3·9368	89	6·2567
23	1·6169	57	4·0071	90	6·3270
24	1·6872	58	4·0774	91	6·3973
25	1·7575	59	4·1477	92	6·4676
26	1·8278	60	4·2180	93	6·5379
27	1·8981	61	4·2883	94	6·6082
28	1·9684	62	4·3586	95	6·6785
29	2·0387	63	4·4289	96	6·7488
30	2·1090	64	4·4992	97	6·8191
31	2·1793	65	4·5695	98	6·8894
32	2·2496	66	4·6398	99	6·9597
33	2·3199	67	4·7101	100	7·0300
34	2·3902				

EQUIVALENTS IN TONS PER SQUARE INCH FOR KILOS PER SQUARE MILLIMETRE.

Kilos per Sq. Millimetre.	Tons per Sq. Inch.	Kilos per Sq. Millimetre.	Tons per Sq. Inch.	Kilos per Sq. Millimetre.	Tons per Sq. Inch.
1	0·6349	35	22·2215	68	43·1732
2	1·2698	36	22·8564	69	43·8081
3	1·9047	37	23·4913	70	44·4430
4	2·5396	38	24·1262	71	45·0779
5	3·1745	39	24·7611	72	45·7128
6	3·8094	40	25·3960	73	46·3477
7	4·4443	41	26·0309	74	46·9826
8	5·0792	42	26·6658	75	47·6175
9	5·7141	43	27·3007	76	48·2524
10	6·3490	44	27·9356	77	48·8873
11	6·9839	45	28·5705	78	49·5222
12	7·6188	46	29·2054	79	50·1571
13	8·2537	47	29·8403	80	50·7920
14	8·8886	48	30·4752	81	51·4269
15	9·5235	49	31·1101	82	52·0618
16	10·1584	50	31·7450	83	52·6967
17	10·7933	51	32·3799	84	53·3316
18	11·4282	52	33·0148	85	53·9665
19	12·0631	53	33·6497	86	54·6014
20	12·6980	54	34·2846	87	55·2363
21	13·3329	55	34·9195	88	55·8712
22	13·9678	56	35·5544	89	56·5061
23	14·6027	57	36·1893	90	57·1410
24	15·2376	58	36·8242	91	57·7759
25	15·8725	59	37·4591	92	58·4108
26	16·5074	60	38·0940	93	59·0457
27	17·1423	61	38·7289	94	59·6806
28	17·7772	62	39·3638	95	60·3155
29	18·4121	63	39·9987	96	60·9504
30	19·0470	64	40·6336	97	61·5853
31	19·6819	65	41·2685	98	62·2202
32	20·3168	66	41·9034	99	62·8551
33	20·9517	67	42·5383	100	63·4900
34	21·5866				

WIRE AND PLATE GAUGES.

Number of Wire Gauge.	Birmingham Wire Gauge. Size in Decimals of an Inch.	Imperial Standard Wire Gauge. Diameter in Decimals of an Inch.	U.S. Standard for Plate. Thickness in Decimals of an Inch.
0000000	..	0·5000	..
000000	..	0·4640	0·4687
00000	..	0·4320	0·4375
0000	0·454	0·4000	0·4062
000	0·425	0·3720	0·3750
00	0·380	0·3480	0·3437
0	0·340	0·3240	0·3125
1	0·300	0·3000	0·2812
2	0·284	0·2760	0·2656
3	0·259	0·2520	0·2500
4	0·238	0·2320	0·2343
5	0·220	0·2120	0·2187
6	0·203	0·1920	0·2031
7	0·180	0·1760	0·1875
8	0·165	0·1600	0·1718
9	0·148	0·1440	0·1562
10	0·134	0·1280	0·1406
11	0·120	0·1160	0·1250
12	0·109	0·1040	0·1093
13	0·095	0·0920	0·0937
14	0·083	0·0800	0·0781
15	0·072	0·0720	0·0703
16	0·065	0·0640	0·0625
17	0·058	0·0560	0·0562
18	0·049	0·0480	0·0500
19	0·042	0·0400	0·0437
20	0·035	0·0360	0·0375
21	0·032	0·0320	0·0343
22	0·028	0·0280	0·0312
23	0·025	0·0240	0·0281
24	0·022	0·0220	0·0250
25	0·020	0·0200	0·0218
26	0·018	0·0180	0·0187
27	0·016	0·0164	0·0171
28	0·014	0·0148	0·0156
29	0·013	0·0136	0·0140
30	0·012	0·0124	0·0125
31	0·010	0·0116	0·0109
32	0·009	0·0108	0·0101
33	0·008	0·0100	0·0093
34	0·007	0·0092	0·0085
35	0·005	0·0084	0·0078
36	0·004	0·0076	0·0070
37	..	0·0068	0·0066
38	..	0·0060	0·0062

ATMOSPHERIC STANDARDS: ENGLISH AND FOREIGN.

One pound per square inch = 2·035 inches of mercury column.

One atmosphere . . = 14·7 lbs. per square inch = 29·9 inches mercury.

The above standard is used in Belgium, England, Holland, Italy, Norway, Portugal, Russia, Spain, Sweden, Switzerland, and the United States.

The metric atmosphere is in use in Austria, France, and Germany.

One metric atmosphere = one kilogramme per square centimetre.
" " = 735 millimetres mercury column.
" " = 14·22 lbs. per square inch.
" " = 28·94 inches of mercury.

ELECTRICAL STANDARDS.

Standards for the measurement of electricity legalised by an Order in Council made on the 23rd August 1894, under the Weights and Measures Act, 1889 (52 and 53 Vict., cap. 21), published in the *London Gazette* of 24th August 1894:—

1. The Ohm, which has the value of 10^9 in the terms of the centimetre, and the second of time, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14·4521 grammes in mass, of a constant cross sectional area, and of a length of 106·3 centimetres.

2. The Ampère, which has the value of 0·1 in terms of the centimetre, the gramme, and the second of time, and which is represented by the unvarying electric current, which, when passed through a solution of nitrate of silver in water, deposits silver at the rate of 0·001118 of a gramme per second.

3. The VOLT, which has the value of 10^8 in terms of the centimetre, the gramme, and the second of time, being the electrical pressure that, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampère, and that is represented by 0·69735 of the electrical pressure at a temperature of 15° C. between the poles of the voltaic cell known as Clark's cell.

In England the "Board of Trade unit" of 1000 watt-hours is the measure of price, a rate of 746 watts being equal to one electrical horse-power.

FORCE OF THE WIND.

The velocity of the wind is ascertained by an instrument known as an anemometer, which, when in use, should be placed with the fan-wheel facing the direction of the wind. The velocity can then be ascertained from the dial by taking the mean of readings for several definite periods recorded by a stop-watch. The pressure in pounds per square foot is $P = 0{\cdot}003\ V^2$ (V = miles per hour).

TABLE SHOWING THE FORCE OF THE WIND AS REGISTERED BY BEAUFORT'S NOTATION.

Miles per Hour registered by Anemometer.	Force.
0 to 3	Calm.
8 to 13	Light airs 1 to 2
18	3
23	4
28	5
34	6
40	7
48	8
56	9
65	10
75	11
90	12

MINERS' INCH.

The unit of measurement of water used by sluice-miners = amount of water hourly discharged through an opening 1 inch square under a head of several inches. If the head is 7 inches and the hole is through a plank 2 inches thick, a miners' inch = about 90 cubic feet per hour

1 miners' inch = 2159 cubic feet per 24 hours = 0·025 cubic feet per second.—Ihlseng, *Manual of Mining*, N.Y., 1898.

In the standards and definitions adopted by the Institution of Mining and Metallurgy the following is given with regard to the "miners' inch":—

"The term 'miners' inch' shall represent a flow of 1·5 cubic feet of water per minute; and the term 'sluice head' shall represent a flow of 60 cubic feet of water per minute.

"*Note.*—It is advisable to abandon the use of both terms, as being merely of local usage, in favour of definite expression of the flow of water per minute, or per second, in cubic feet or in gallons."

WATER SUPPLY FOR HEADQUARTERS.

For each man, woman, and child in temperate climates, allow for house supply .	18 to 20 gallons per day.
In tropical climates allow .	22 to 25 ,, ,,
A large bath requires about 40 gallons.	
A water-closet requires for each flushing from $1\frac{1}{2}$ to 2 gallons.	
Each horse (including washing) about . . .	15 gallons per day.
A cow will consume about .	8 ,, ,,
A mule ,, ,, ,, .	6 ,, ,,
A camel ,, ,, ,, .	10 ,, ,,
A sheep or pig will consume about . . .	1 gallon per day.

CAPACITY OF WHEELBARROWS.

A light wheelbarrow holds $\frac{1}{18}$ cubic yard.
An ordinary wheelbarrow holds $\frac{1}{14}$ cubic yard.
A large (navvy) wheelbarrow holds $\frac{1}{10}$ cubic yard.

MEASUREMENTS OF CHAIN AND ROPE.

Chain or cable is measured by the diameter of the iron of which each link is made.

Rope is usually measured by its circumference, but in the United States of America by its diameter.

MISCELLANEOUS MEASURES.

A dozen	=12 articles.
A score	=20 ,,
A gross	=144 ,,
12 gross	=1 great gross.
1 chaldron	=12 sacks.
1 sack of coal . . .	=1 cwt.
1 large sack of coal . .	=2 ,,
A seam of glass . . .	=120 lbs.
1 ton Portland cement . .	=10 sacks or 6 casks.
1 ton of freight by measurement	=40 cubic feet.
A faggot of steel . .	=120 lbs.
A barrel of tar . . .	=25 gallons.

THE CIRCLE AND ITS SECTIONS.

Observations and Definitions.

1. The circle contains a greater area than any other plane figure bounded by the same perimeter or outline.

2. The areas of circles are to each other as the squares of their diameters; any circle twice the diameter of another contains four times the area of the other.

3. The radius of a circle is a straight line drawn from the centre to the circumference, as OB (see fig. 38).

4. The diameter of a circle is a straight line drawn

through the centre, and terminating both ways at the circumference, as COA.

5. A chord is a straight line joining any two points of the circumference, as DF.

6. The versed sine is a perpendicular joining the middle of the chord and circumference, as EG.

7. An arc is any part of the circumference, as CDE.

8. A semi-circle is half the circumference cut off by a diameter, as CEA.

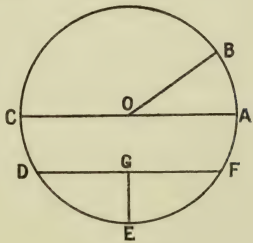


FIG. 38.

9. A segment is any portion of a circle cut off by a chord, as DEF.

10. A sector is a part of a circle cut off by two radii, as AOB.

GENERAL RULES IN RELATION TO THE CIRCLE.

1. Multiply the diameter by 3·1416, the product is the circumference.

2. Multiply the circumference by 0·31831, the product is the diameter.

3. Multiply the square of the diameter by 0·7854, the product is the area.

4. Multiply the square root of the area by 1·12837, the product is the diameter.

5. Multiply the diameter by 0·8862, the product is the side of a square of equal area.

6. Multiply the side of a square by 1·123, the product is the diameter of a circle of equal area.—*The Modernised Templeton*, by W. S. Hutton, 1895.

STANDARD OF MEASUREMENT FOR IRON.

At a special meeting of the Iron Trade, held on 28th February 1896, it was resolved that the standard of measurement for iron of all description shall in future be the Birmingham gauge. It was further decided that the annexed table of decimal equivalents be adopted as corresponding with the numbers on the gauge.

	Number of Birmingham Gauge.	Fractions of an Inch.	Decimal Equivalents of an Inch.		Number of Birmingham Gauge.	Fractions of an Inch.	Decimal Equivalents of an Inch.
Plates.	000	$\frac{1}{2}$	0·5	Sheets.	15	..	0·0699
	00	..	0·4452		16	$\frac{1}{16}$	0·0625
	0	..	0·3964		17	..	0·0556
	1	..	0·3532		18	..	0·0495
	2	..	0·3147		19	..	0·044
	3	..	0·2804		20	..	0·0392
	4	$\frac{1}{4}$	0·25		21		0·0349
	5	..	0·2225		22	$\frac{1}{32}$	0·03125
	6	..	0·1981		23	..	0·0278
Sheets.	7	..	0·1764		24	..	0·0247
	8	..	0·157		25	..	0·022
	9	..	0·1398		26	..	0·0196
	10	$\frac{1}{8}$	0·125		27	..	0·0174
	11	..	0·1113		28	$\frac{1}{64}$	0·015625
	12	..	0·0991		29	..	0·0139
	13	..	0·0882		30	..	0·0123
	14	..	0·0785				

Newbigging.

WEIGHT IN POUNDS OF SHEET IRON AND STEEL.

Number of Birmingham Wire Gauge.	Thickness in parts of an Inch. Board of Trade Standard.	Weight per Square Feet in Lbs.	
		Iron.	Steel.
1	0·300	12·00	12·240
2	0·284	11·36	11·587
3	0·260	10·40	10·608
4	0·238	9·52	9·710
5	0·220	8·80	8·976
6	0·203	8·12	8·282
7	0·180	7·20	7·344
8	0·165	6·60	6·732
9	0·148	5·92	6·038
10	0·135	5·40	5·508
11	0·120	4·80	4·896
12	0·109	4·36	4·447
13	0·095	3·80	3·876
14	0·083	3·32	3·386
15	0·072	2·88	2·938
16	0·065	2·60	2·652
17	0·058	2·32	2·366
18	0·050	2·00	2·040
19	0·041	1·64	1·673
20	0·035	1·40	1·428
21	0·032	1·28	1·306
22	0·028	1·12	1·142
23	0·025	1·00	1·020
24	0·022	0·88	0·898
25	0·020	0·80	0·816
26	0·018	0·72	0·734
27	0·016	0·64	0·653
28	0·014	0·56	0·571
29	0·013	0·52	0·530
30	0·012	0·48	0·490
31	0·010	0·40	0·408
32	0·009	0·36	0·367
33	0·008	0·32	0·326
34	0·007	0·28	0·286
35	0·005	0·20	0·240
36	0·004	0·16	0·163

Newbigging.

WEIGHT AND STRENGTH OF ROUND ROPES OF HEMP AND WIRE.

Hemp.

Girth or Circumference in Inches.	Weight per Fathom of 6 Feet in Lbs.	Breaking Weight in Tons.
$\frac{3}{4}$	0·15	$\frac{1}{9}$
1	0·26	$\frac{1}{5}$
$1\frac{1}{2}$	0·59	$\frac{1}{2}$
2	1·04	$\frac{4}{5}$
$2\frac{1}{2}$	1·70	$1\frac{1}{4}$
$2\frac{3}{4}$	2·00	$1\frac{1}{2}$
3	2·34	$1\frac{4}{5}$
$3\frac{1}{2}$	3·19	$2\frac{1}{2}$
$3\frac{3}{4}$	3·66	$2\frac{4}{5}$
4	4·16	$3\frac{1}{5}$
$4\frac{1}{2}$	5·27	4
5	6·50	5
$5\frac{1}{2}$	7·86	6
6	9·36	$7\frac{1}{4}$
$6\frac{1}{2}$	11·00	$8\frac{1}{2}$
7	12·74	$9\frac{3}{4}$
$7\frac{1}{2}$	14·63	$11\frac{1}{4}$
8	16·64	$12\frac{3}{4}$
$8\frac{1}{2}$	18·78	$14\frac{1}{2}$
9	21·06	$16\frac{1}{4}$
$9\frac{1}{2}$	23·46	18
10	26·00	20
$10\frac{1}{2}$	28·66	22
11	31·46	$24\frac{1}{4}$
$11\frac{1}{2}$	34·38	$26\frac{1}{2}$
12	37·44	29

WEIGHT AND STRENGTH OF ROUND ROPES OF HEMP AND WIRE—*continued.*

IRON WIRE.

Girth or Circumference in Inches.	Weight per Fathom of 6 Feet in Lbs.	Breaking Weight in Tons.
$\frac{3}{4}$	$\frac{1}{2}$	$\frac{7}{8}$
1	1	$1\frac{1}{2}$
$1\frac{1}{2}$	$1\frac{1}{2}$	$3\frac{1}{4}$
$1\frac{5}{8}$	2	4
$1\frac{3}{4}$	$2\frac{1}{2}$	$4\frac{1}{2}$
$1\frac{7}{8}$	3	$5\frac{1}{4}$
2	$3\frac{1}{2}$	6
$2\frac{1}{8}$	4	$6\frac{3}{4}$
$2\frac{1}{4}$	$4\frac{1}{2}$	$7\frac{1}{2}$
$2\frac{3}{8}$	5	$8\frac{1}{4}$
$2\frac{1}{2}$	$5\frac{1}{2}$	$9\frac{1}{4}$
$2\frac{5}{8}$	6	$10\frac{1}{4}$
$2\frac{3}{4}$	$6\frac{1}{2}$	$11\frac{1}{4}$
$2\frac{7}{8}$	7	$12\frac{1}{4}$
3	$7\frac{1}{2}$	$13\frac{1}{2}$
$3\frac{1}{8}$	8	$14\frac{1}{2}$
$3\frac{1}{4}$	$8\frac{1}{2}$	16
$3\frac{3}{8}$	9	17
$3\frac{1}{2}$	10	$18\frac{1}{2}$
$3\frac{5}{8}$	11	$19\frac{3}{4}$
$3\frac{3}{4}$	12	21
$3\frac{7}{8}$	13	$22\frac{1}{2}$
4	14	24
$4\frac{1}{4}$	15	27
$4\frac{3}{8}$	16	$28\frac{3}{4}$
$4\frac{1}{2}$	18	$30\frac{1}{4}$
$4\frac{5}{8}$	20	32
5	25	38
$5\frac{1}{2}$	32	$45\frac{1}{2}$
6	38	54

Weight and Strength of Round Ropes of Hemp and Wire—*continued.*

Steel Wire.

Girth or Circumference in Inches.	Weight per Fathom of 6 Feet in Lbs.	Breaking Weight in Tons.
1	1	2½
1¼	1¼	3¾
1⅜	1½	4¾
1½	1¾	5½
1⅝	2	6½
1¾	2¼	7½
1⅞	2¾	8¾
2	3¼	10
2⅛	3¾	11¼
2¼	4¼	12½
2⅜	4¾	14
2½	5¼	15½
2⅝	5¾	17¼
2¾	6¼	19
2⅞	6¾	20½
3	7¼	22½
3⅛	7½	24½
3¼	8	26½
3⅜	8 (*sic*)	28½
3½	10	30½
3¾	12	35
4	15	40

Newbigging.

DATA RELATING TO WATER.

Cubic feet per minute × 9000 = gallons per 24 hours.

Diam.^{2} of pipe in inches = pounds of water per yard.

Head in feet × 0·434 = pounds pressure per square inch.

Pounds per square inch × 2·3 = foot-head.

Tons × 224 = gallons.

The freezing-point under a pressure of one atmosphere is 32° F., or 0° C.

The point of maximum density is 39·1° F., or 4° C.

The British standard temperature is 62° F., or 16·66° C., though the specific gravity of liquids is usually determined at 60° F., or 15·55° C.

The boiling-point under a pressure of one atmosphere is 212° F., or 100° C.

1 cwt. of water = 1·8 cubic feet = 11·2 gallons.

1 ton of water = 35·9 cubic feet = 224 gallons.

Weight and Capacity of English and American Standard Gallons of Water.

	Cubic Inches in a Gallon.	Weight of a Gallon in Lbs.	Gallons in a Cubic Foot.
Imperial . at 62° F.	277·274	10·00	6·232102
United States at 62° F.	231	8·33111	7·480519

PRESSURE EXERTED BY WATER.

In Pounds per Square Inch per Foot-head.

Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.
1	0·434	28	12·152	55	23·870
2	0·868	29	12·586	56	24·304
3	1·302	30	13·020	57	24·738
4	1·736	31	13·454	58	25·172
5	2·170	32	13·888	59	25·606
6	2·604	33	14·322	60	26·040
7	3·038	34	14·756	61	26·474
8	3·472	35	15·190	62	26·908
9	3·906	36	15·624	63	27·342
10	4·340	37	16·058	64	27·776
11	4·774	38	16·492	65	28·210
12	5·208	39	16·926	66	28·644
13	5·642	40	17·360	67	29·078
14	6·076	41	17·794	68	29·512
15	6·510	42	18·228	69	29·946
16	6·944	43	18·662	70	30·380
17	7·378	44	19·096	71	30·814
18	7·812	45	19·530	72	31·248
19	8·246	46	19·964	73	31·682
20	8·680	47	20·398	74	32·116
21	9·114	48	20·832	75	32·550
22	9·548	49	21·266	76	32·984
23	9·982	50	21·700	77	33·418
24	10·416	51	22·134	78	33·852
25	10·850	52	22·568	79	34·286
26	11·284	53	23·002	80	34·720
27	11·718	54	23·436	81	35·154

PRESSURE EXERTED BY WATER.—*Continued.*

Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.
82	35·588	450	195·300	1750	759·500
83	36·022	500	217·000	1800	781·200
84	36·456	550	238·700	1850	802·900
85	36·890	600	260·400	1900	824·600
86	37·324	650	282·100	1950	846·300
87	37·758	700	303·800	2000	868·000
88	38·192	750	325·500	2050	889·700
89	38·626	800	347·200	2100	911·400
90	39·060	850	368·900	2150	933·100
91	39·494	900	390·600	2200	954·800
92	39·928	950	412·300	2250	976·500
93	40·362	1000	434·000	2300	998·200
94	40·796	1050	455·700	2350	1019·900
95	41·230	1100	477·400	2400	1041·600
96	41·664	1150	499·100	2450	1063·300
97	42·098	1200	520·800	2500	1085·000
98	42·532	1250	542·500	2550	1106·700
99	42·966	1300	564·200	2600	1128·400
100	43·400	1350	585·900	2650	1150·100
125	54·250	1400	607·600	2700	1171·800
150	65·100	1450	629·300	2750	1193·500
175	75·950	1500	651·000	2800	1215·200
200	86·800	1550	672·700	2850	1236·900
250	108·500	1600	694·400	2900	1258·600
300	130·200	1650	716·100	2950	1280·300
350	151·900	1700	737·800	3000	1302·000
400	173·600				

ENGLISH STATUTE MILE COMPARED WITH OTHER STANDARD MEASUREMENTS.

English Statute Mile.	English Geo. Mile.	Kilo-metre.	German Geo. Mile.	Russian Verst.	Austrian Mile.
1	1·153	0·621	4·610	0·663	4·714

[TABLE.

TRAVERSE TABLE.

C=Course in degrees. APPLICABLE TO ANY RIGHT-ANGLED TRIANGLE BY TAKING C=Angle, Diff. lat.=Base, Departure=Perpendicular, Dist.=Hypothenuse.

C.°	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		
	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep	Diff lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	
1	1·00	·017	2·00	·035	3·00	·052	4·00	·070	5·00	·087	6·00	·105	7·00	·122	8·00	·139	9·00	·157	89
2	·999	·035	2·00	·070	3·00	·105	4·00	·140	5·00	·174	6·00	·209	7·00	·244	8·00	·279	8·99	·314	88
3	·999	·052	2·00	·105	3·00	·157	3·99	·209	4·99	·262	5·99	·314	6·99	·366	7·99	·419	8·99	·471	87
4	·998	·070	2·00	·139	2·99	·209	3·99	·279	4·99	·349	5·99	·418	6·98	·488	7·98	·558	8·98	·628	86
5	·996	·087	1·99	·174	2·99	·261	3·98	·349	4·98	·436	5·98	·523	6·97	·601	7·97	·697	8·97	·784	85
6	·994	·104	1·99	·209	2·98	·314	3·98	·418	4·97	·523	5·97	·627	6·96	·732	7·96	·836	8·95	·941	84
7	·992	·122	1·99	·244	2·98	·366	3·97	·487	4·96	·609	5·96	·731	6·95	·853	7·94	·975	8·93	1·10	83
8	·990	·140	1·98	·278	2·97	·417	3·96	·557	4·95	·696	5·94	·835	6·93	·974	7·92	1·11	8·91	1·25	82
9	·987	·156	1·98	·313	2·96	·469	3·95	·626	4·94	·782	5·93	·939	6·91	1·10	7·90	1·25	8·89	1·41	81
10	·985	·174	1·97	·347	2·95	·521	3·94	·694	4·92	·868	5·91	1·04	6·89	1·22	7·88	1·39	8·86	1·56	80
11	·982	·191	1·96	·381	2·94	·572	3·93	·763	4·91	·954	5·89	1·14	6 87	1·34	7·85	1·53	8·83	1·72	79
12	·978	·208	1·96	·416	2·93	·624	3·91	·832	4·89	1·04	5·87	1·25	6·85	1·46	7·83	1·66	8·80	1·87	78
13	·974	·225	1·95	·450	2·92	·675	3·90	·900	4·87	1·12	5·85	1·35	6·82	1·57	7·79	1·80	8·77	2·02	77
14	·970	·242	1·94	·484	2·92	·726	3·88	·970	4·85	1·21	5·82	1·45	6·79	1·69	7·76	1·94	8·73	2·18	76
15	·966	·259	1·93	·518	2·90	·776	3·86	1·04	4·83	1·29	5·80	1·55	6·76	1·81	7·73	2·07	8·69	2·33	75
16	·961	·276	1·92	·551	2·88	·827	3·85	1·10	4·81	1·38	5·77	1·65	6·73	1·93	7·69	2·21	8·65	2·48	74
17	·956	·292	1·91	·585	2·87	·877	3·83	1·17	4·78	1·46	5·74	1·75	6·69	2·05	7·65	2·34	8·61	2·63	73
18	·951	·309	1·90	·618	2·85	·927	3·80	1·24	4·76	1·55	5·71	1·85	6·66	2·16	7·61	2·47	8·56	2·78	72
19	·945	·326	1·89	·651	2·84	·977	3·78	1·30	4·73	1·63	5·67	1·95	6·62	2·28	7·56	2·60	8·51	2·93	71
20	·940	·342	1·88	·684	2·82	1·03	3·76	1·37	4·70	1·71	5·64	2·05	6·58	2·39	7·52	2·74	8·46	3·08	70
21	·934	·358	1·87	·717	2·80	1·07	3·73	1·43	4·67	1·79	5·60	2·15	6·54	2·51	7·47	2·87	8·40	3·23	69
22	·927	·375	1·85	·749	2·78	1·12	3·71	1·50	4·64	1·87	5·56	2·25	6·49	2·62	7·42	3·00	8·34	3·37	68
23	·920	·391	1·84	·781	2·76	1·17	3·68	1·56	4·60	1·95	5·52	2·34	6·44	2·74	7·36	3·13	8·28	3·52	67
24	·913	·407	1·83	·813	2·74	1·22	3·65	1·63	4·57	2·03	5·48	2·44	6·39	2·85	7 31	3·25	8·22	3·66	66
	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	C.°
	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		

TRAVERSE TABLE—*continued.*

C.°	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		
	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	
25	·906	·423	1·81	·845	2·72	1·27	3·63	1·69	4·53	2·11	5·44	2·54	6·34	2·96	7·25	3·38	8·16	3·80	65
26	·899	·438	1·80	·876	2·70	1·32	3·60	1·75	4·49	2·19	5·39	2·63	6·29	3·07	7·19	3·51	8·09	3·95	64
27	·891	·454	1·78	·908	2·67	1·36	3·56	1·82	4·46	2·27	5·35	2·72	6·24	3·18	7·13	3·63	8·09	4·09	63
28	·883	·469	1·77	·939	2·65	1·41	3·53	1·88	4·41	2·35	5·30	2·82	6·18	3·29	7·06	3·76	7·95	4·23	62
29	·875	·485	1·75	·970	2·62	1·45	3·50	1·94	4·37	2·42	5·25	2·91	6·12	3·39	7·00	3·88	7·87	4·36	61
30	·866	·500	1·73	1·00	2·60	1·50	3·46	2·00	4·33	2·50	5·20	3·00	6·06	3·50	6·93	4·00	7·79	4·50	60
31	·857	·515	1·71	1·03	2·57	1·55	3·43	2·06	4·29	2·58	5·14	3·09	6·00	3·61	6·86	4·12	7·71	4·64	59
32	·848	·530	1·70	1·06	2·54	1·59	3·39	2·12	4·24	2·65	5·09	3·18	5·94	3·71	6·78	4·24	7·63	4·77	58
33	·839	·545	1·68	1·09	2·52	1·63	3·35	2·18	4·19	2·72	5·03	3·27	5·87	3·81	6·71	4·36	7·55	4·90	57
34	·829	·559	1·66	1·12	2·49	1·68	3·32	2·24	4·15	2·80	4·97	3·36	5·80	3·91	6·63	4·47	7·46	5·03	56
35	·819	·574	1·64	1·15	2·46	1·72	3·28	2·29	4·10	2·87	4·91	3·44	5·73	4·02	6·55	4·59	7·37	5·16	55
36	·809	·588	1·62	1·18	2·43	1·76	3·24	2·35	4·05	2·94	4·85	3·53	5·66	4·11	6·47	4·70	7·28	5·29	54
37	·799	·602	1·60	1·20	2·40	1·81	3·19	2·41	3·99	3·01	4·79	3·61	5·59	4·21	6·39	4·81	7·19	5·42	53
38	·788	·616	1·58	1·23	2·36	1·85	3·15	2·46	3·94	3·08	4·73	3·69	5·52	4·31	6·30	4·93	7·09	5·54	52
39	·777	·629	1·55	1·26	2·33	1·89	3·11	2·52	3·89	3·15	4·66	3·78	5·44	4·41	6·22	5·03	6·99	5·66	51
40	·766	·643	1·53	1·29	2·30	1·93	3·06	2·57	3·83	3·21	4·60	3·86	5·36	4·50	6·13	5·14	6·89	5·79	50
41	·754	·656	1·51	1·31	2·26	1·97	3·02	2·62	3·77	3·28	4·53	3·94	5·28	4·59	6·04	5·25	6·79	5·90	49
42	·743	·669	1·49	1·34	2·23	2·01	2·97	2·68	3·72	3·35	4·46	4·01	5·20	4·68	5·95	5·35	6·69	6·02	48
43	·731	·682	1·46	1·36	2·19	2·05	2·93	2·73	3·66	3·41	4·39	4·09	5·12	4·77	5·85	5·46	6·58	6·14	47
44	·719	·695	1·44	1·39	2·16	2·08	2·88	2·78	3·60	3·47	4·32	4·17	5·04	4·86	5·75	5·56	6·47	6·25	46
45	·707	·707	1·41	1·41	2·12	2·12	2·83	2·83	3·54	3·54	4·24	4·24	4·95	4·95	5·66	5·66	6·36	6·36	45
	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	Dep.	Diff. lat.	C.°
	Dist. 1.		Dist. 2.		Dist. 3.		Dist. 4.		Dist. 5.		Dist. 6.		Dist. 7.		Dist. 8.		Dist. 9.		

This table may also be used to find difference of longitude from departure as follows :—Take the departure as diff. lat., take mean latitude as course, then corresponding distance=the diff. long. required.

This is approximate, but sufficiently accurate for dead reckoning. *Molesworth.*

PART VIII.

MISCELLANEOUS.

LIST OF THE MORE IMPORTANT WORKS RELATING TO PETROLEUM.

English.

ARCHBUTT, L., and R. M. DEELEY. Lubrication and Lubricants. 8vo. *London.* Ed. iii., 1912.

ASKLING, C. W., and E. ROESLER. Internal Combustion Engines and Gas-Producers. *London.*

BOOTH, W. H. Liquid Fuel and its Combustion. 8vo. *London*, 1903.

BRANNT, W. T. A Practical Treatise on Animal and Vegetable Oils; . . . including Mineral Lubricating Oils, etc., and on Ozokerite. *Philadelphia*, 1888. Ed. ii., 1896.

—— Petroleum: Its History, Origin, Occurrence, Production, Physical and Chemical Constitution, Technology, Examination, and Uses. *Philadelphia* and *London*, 1895.

BUTLER, E. Internal Combustion Engines. *London*, 1912.

—— Carburettors, Vaporisers, etc. *London*, 1909.

—— Oil Fuel: Its Supply, Composition, and Application. *London.* Ed. iii., 1914.

CLERK, D. The Gas, Oil, and Petrol Engine. Vol. i. *London*, 1909.

CLOWES, F., and B. REDWOOD. The Detection and Measurement of Inflammable Gas and Vapour in the Air. 8vo. *London*, 1896.

COOPER-KEY, A. Storage of Petroleum Spirit. *London*, 1914.

Craig, E. H. C. Oil Finding: An Introduction to the Geological Study of Petroleum. *London*, 1912.

Crew, B. J. A Practical Treatise on Petroleum; comprising its Origin, Geology, Geographical Distribution, History, Chemistry, Mining, Technology, Uses, and Transportation. . . . 8vo. *Philadelphia*, 1887.

Delano, W. H. Twenty Years' Practical Experience of Natural Asphalt and Mineral Bitumen. 8vo. *London* and *New York*, 1893.

Donkin, B., and Others. Gas, Oil, and Air Engines. *London*. Ed. v., 1911.

Henry, J. D. Baku. *London*, 1905.

—— Thirty-five Years of Oil Transport. *London*, 1907.

—— Oil Fuel and the Empire. *London*, 1908.

—— Oil Fields of the Empire. Vol. i.: Trinidad and Newfoundland. Vol. ii.: New Zealand. *London*. 1910–1911.

Hicks, J. Laboratory Book of Mineral Oil Analysis. *London*. Ed. ii., 1912.

Lewes, V. B. Liquid and Gaseous Fuels and the part they play in Modern Power Production. *London*, 1911.

Lieckfeld, G. Oil Motors. *London*, 1908.

Marvin, C. The Petroleum Industry of Southern Russia. 4to. *London*, 1884.

—— The Region of the Eternal Fire; an Account of a Journey to the Petroleum Region of the Caspian in 1883. 8vo. *London*, 1884. Ed. ii., 1888.

—— The Petroleum of the Future. Baku, the Petrolia of Europe. 8vo. *London*, 1883.

—— The Moloch of Paraffin. 8vo. *London*, 1886.

—— The Coming Deluge of Russian Petroleum, and its Bearings on British Trade. 1887.

—— England as a Petroleum Power, or the Petroleum Fields of the British Empire. *London*, 1887.

—— Our Unappreciated Petroleum Empire. 8vo. *London*, 1889.

MARVIN, C. The Coming Oil Age: Petroleum—Past, Present, and Future. Pp. 32. 8vo. *London*, 1889.

MILLS, E. J. Destructive Distillation: a Manualette of the Paraffin, Coal-Tar, Rosin Oil, Petroleum, and Kindred Industries. *London*, 1887. Ed. iv., 1892.

REDWOOD, B. Petroleum: a Treatise on the Geographical Distribution and Geological Occurrence of Petroleum and Natural Gas; the Physical and Chemical Properties, Production, and Refining of Petroleum and Ozokerite; the Character and Uses, Testing, Transport, and Storage of Petroleum Products, and the Legislative Enactments relating thereto; together with a Description of the Shale Oil and Allied Industries. 3 vols. *London*, 1896. Ed. iii., 1913.

REDWOOD, I. I. A Practical Treatise on Mineral Oils and their By-Products. Including a Short History of the Scotch Shale Oil Industry. . . . 8vo. *London* and *New York*, 1897.

THOMPSON, A. B. The Oilfields of Russia. *London*, 1908.

—— Petroleum Mining and Oilfield Development. *London*, 1910.

THOMSON, J. H., and B. REDWOOD. Handbook on Petroleum for Inspectors under the Petroleum Acts. . . . 8vo. *London*. Ed. iii., 1913.

—— The Petroleum Lamp, its Choice and Use. . . . *London*, 1902.

GERMAN.

AISINMANN, S. Taschenbuch für die Mineralöl-Industrie. 8vo. *Berlin*, 1896.

BERLINERBLAU, J. Das Erdwachs, Ozokerit und Ceresin. (Bolley's *Chem. Technol.*, No. 57.) 8vo. *Brunswick*, 1897.

ENGLER, C., and H. HÖFER. Das Erdöl.

HÖFER, H. Das Erdöl (Petroleum) und seine Verwandten. . . . *Brunswick*, 1888.

MUCK, J. Der Erdwachsbergbau in Boryslaw. *Berlin*, 1903.

SINGER, L. Beiträge zur Theorie der Petroleum-bildung. *Zürich*, 1892.

TECKLENBURG, T. Handbuch der Tiefbohrkunde. 6 Bde. *Leipzig*, 1886–1896.

VEITH, A. Das Erdöl und seine Verarbeitung. *Brunswick*, 1892.

FRENCH.

DEUTSCH (DE LA MEURTHE), HENRY. Le Pétrole et ses Applications. *Paris*, N.D.

JACCARD, A. Le Pétrole, l'Asphalte, et le Bitume au point de vue géologique. *Paris*, 1895.

NEUBURGER, H., and H. NOALHAT. Technologie du Pétrole. *Paris*, 1899.

RICHE, A., and G. HALPHIN. Le Pétrole. *Paris*, 1896.

LIST OF OIL NEWSPAPERS AND JOURNALS.

Name.	Editor.	Published at	Language.
The Petroleum Review . .	Albert Lidgett.	London.	English.
Oil News	J. T. Smith.	,,	,,
The Petroleum World . .	J. T. Smith.	,,	,,
Moniteur du Pétrole Romain .	N. Mancas.	Bucarest.	French and Rumanian.
Naphta	Prof. R. Zaloziecki and Dr. S. Bartoszewicz.	Lemberg, Galicia.	Polish.
Allgemeine österr. Chemiker- und Techniker-Zeitung.	Hans Urban.	Vienna.	German.
California Derrick . . .	Edward S. Eastman.	San Francisco, California.	English.
The Oil Industry . . .	Allen G. Nichols.	Los Angeles, California.	,,
The California Oil World . .	Chas. P. Fox.	Bakersfield, California.	,,
Coalinga Oil Record . .	S. D. Porter.	Coalinga, California.	,,
The Petroleum Gazette . .	F. F. & J. Murray.	Titusville, Pennsylvania.	,,
Oil City Derrick . . .	Pat. Boyle.	Oil City, Pennsylvania.	,,
Petroleum	Dr. Paul Schwarz.	Berlin.	German.
Journal du Pétrole . .	..	Paris.	French.
The Oil and Gas Journal (The Oil Investors' Journal).	Thos. A. Latta.	Tulsa, Oklahoma.	English.
Revue du Pétrole . . .	G. M. Murgoci.	Bucarest.	French and Rumanian.
Neftianoie Dielo . . .	..	Baku.	Russian.

ABBREVIATIONS AND CONTRACTIONS IN GENERAL USE.

A.C.G.I.	Associate of City and Guilds of London Institute.
A.I.C.	Associate of the Institute of Chemistry.
A.I.C.A.	Associate of the Institute of Chartered Accountants.
Assoc.Inst.C.E.	Associate of the Institution of Civil Engineers.
Assoc.Inst.M.E.	Associate of the Institution of Mining Engineers.
Assoc.Inst.M.M.	Associate of the Institution of Mining and Metallurgy.
Assoc.Inst.P.T.	Associate of the Institution of Petroleum Technologists.
Assoc.M.Inst.M.E.	Associate Member of the Institution of Mining Engineers.
A.M.Inst.C.E.	Associate Member of the Institution of Civil Engineers.
A.M.Inst.M.M.	Associate Member of the Institution of Mining and Metallurgy.
A.M.I.Mech.E.	Associate Member of the Institution of Mechanical Engineers.
A.M.Inst.P.T.	Associate Member of the Institution of Petroleum Technologists.
A.R.C.Sc.	Associate of the Royal College of Science.
A.R.I.B.A.	Associate of the Royal Institution of British Architects.
A.R.S.M.	Associate of the Royal School of Mines.
B.	Baumé.
B.A.	Bachelor of Arts.
B.H.P.	Brake horse-power.
B/L.	Bill of Lading.
B.O.V.	Brown oil of vitriol.

B.P.	Boiling-point.
B.Sc.	Bachelor of Science.
B.T.U.	Board of Trade unit (Electrical).
B.Th.U.	British thermal unit.
B.W.G.	Birmingham wire gauge.
C.	Centigrade or Celsius.
C.A.	Chartered Accountant.
C. & F.	Cost and freight.
Cal. or Calif.	California.
C.E.	Civil Engineer.
Cf.	Compare.
C.G.S.	Centimetre—gramme—second.
C.I.F.	Cost, insurance, and freight.
C.O.D.	Cash on delivery.
Con.	Contra, against.
D. Phil.	Doctor of Philosophy.
D.Sc.	Doctor of Science.
E.E.	Errors excepted.
E.g.	(*Exempli gratia.*) For example.
E. & O.E.	Errors and omissions excepted.
Et al.	(*Et alibi.*) And elsewhere.
Et seq.	(*Et seqitur.*) And the following.
F., Fahr.	Fahrenheit.
F.A.A.	Free of all average.
F.A.S.	Free alongside.
F.C.A.	Fellow of the Institute of Chartered Accountants.
F.C.I.S.	Fellow of the Chartered Institute of Secretaries.
F.C.S.	Fellow of the Chemical Society.
F.G.A.	Free of general average.
F.G.S.	Fellow of the Geological Society.
F.I.A.	Fellow of the Institute of Actuaries.
F.I.C.	Fellow of the Institute of Chemistry.
F.I.D.	Fellow of the Institute of Directors.
F.O.B.	Free on board.
F.O.R.	Free on rail.

Abbreviations and Contractions in General Use—*continued*.

F.P.	Flashing-point.
F.P.S.	Foot—pound—second.
F.R.C.I.	Fellow of the Royal Colonial Institute.
F.R.G.S.	Fellow of the Royal Geographical Society.
F.R.I.B.A.	Fellow of the Royal Institution of British Architects.
F.R.S.	Fellow of the Royal Society.
F.R.S.E.	Fellow of the Royal Society of Edinburgh.
F.S.G.	Fellow of the British Science Guild.
F.S.I.	Fellow of the Surveyors' Institution.
H.P.	Horse-power. High pressure.
H.W.M.	High-water mark.
Ib.	(*Ibidem.*) In the same place.
Id.	(*Idem.*) The same.
I.e.	(*Id est.*) That is.
I.H.P.	Indicated horse-power.
Ill.	Illinois.
Ind.	Indiana.
Inst.	Instant, the present month.
Kan.	Kansas.
Ky.	Kentucky.
La.	Louisiana.
Lat.	Latitude.
L.c.	(*Loco citato.*) In the place quoted.
L/c.	Letter of credit.
Lon., or Long.	Longitude.
L.P.	Low pressure.
M.A.	Master of Arts.
M.E.	Mining Engineer.
M.E.P.	Mean effective pressure.
M.Inst.C.E.	Member of the Institution of Civil Engineers.

M.I.E.E.	Member of the Institution of Electrical Engineers.
M.I.Mech.E.	Member of the Institution of Mechanical Engineers.
M.Inst.M.E.	Member of the Institution of Mining Engineers.
M.Inst.M.M.	Member of the Institution of Mining and Metallurgy.
M.Inst.P.T.	Member of the Institution of Petroleum Technologists.
Mo.	Missouri.
M.P.	Melting-point.
M.P.H.	Miles per hour.
MS.	Manuscript. Plural MSS.
M.Sc.	Master of Science.
Nem. con.	(*Nemine contradicente.*) Without opposition.
Nem. dis.	(*Nemine dissentiente.*) No person disagreeing, unanimous.
Net.	(*Netto.*) Lowest.
N.F.	Newfoundland.
N.H.P.	Nominal horse-power (practically obsolete).
Non obst.	(*Non obstante.*) Notwithstanding.
Non seq.	(*Non sequitur.*) It does not follow.
N.P.	Notary Public.
N.S.	New style. Nova Scotia.
N.Y.	New York.
O.	Ohio.
Okla.	Oklahoma.
Op. cit.	(*Opere citato.*) In the work cited.
O.S.	Old style. (Greek and Russian Calendars.)
Pa.	Pennsylvania.
Pat.	Patent.
Ph.D.	Doctor of Philosophy.
Prox.	(*Proximo.*) Next.

ABBREVIATIONS AND CONTRACTIONS IN GENERAL USE—*continued.*

Q.v.	(*Quod vide.*) Which see.
R.	Réaumur.
R.E.	Royal Engineers.
Sp. Gr.	Specific gravity.
Sp. Ht.	Specific heat.
S.W.G.	Standard wire gauge.
Tenn.	Tennessee.
Tex.	Texas.
Ult.	(*Ultimo.*) Last.
V.	(*Versus.*) Against.
Via.	By the way of.
Viz.	(*Videlicet.*) Namely.
W.S.	Writer to the Signet.
W.Va.	West Virginia.
Wyo.	Wyoming.

REGULATIONS RESPECTING PASSPORTS.

1. Applications for Foreign Office Passports must be made on a printed form obtainable from "THE PASSPORT OFFICE, FOREIGN OFFICE, Downing Street, London, S.W."

2. The charge for a Passport, whatever number of persons may be named in it, is two shillings. Passports are issued at the Foreign Office between the hours of 11 and 4 ON THE DAY FOLLOWING THAT ON WHICH THE APPLICATION FOR THE PASSPORT HAS BEEN RECEIVED, except on Sundays and Public Holidays, when the Passport Office is closed. Applications should, if possible, reach the Passport Office before 4 p.m. on the previous day. If the applicant does not reside in London, the Passport may be sent by post, and a Postal Order for two shillings should in that case accompany the

application. Postage stamps will not be received in payment.

3. Foreign Office Passports are granted—

(1) To natural-born British subjects, viz. persons born within His Majesty's Dominions, and to persons born abroad who derive British nationality from a father or paternal grandfather born within His Majesty's Dominions, and who, under the provisions of the Acts 4 George II., cap. 21, and 13 George III., cap. 21, are to be adjudged and taken to be natural-born British subjects.
(2) To the wives and widows of such persons; and
(3) To persons naturalised in the United Kingdom, in the British Colonies, or in India.

A married woman is deemed to be a subject of the State of which her husband is for the time being a subject.

4. Passports are granted to such persons as are known to the Secretary of State, or recommended to him by some person who is known to him; or—

(1) In the case of natural-born British subjects and persons naturalised in the United Kingdom, upon the production of a declaration by the applicant in the authorised form, verified by a declaration made by any Banking Firm established in the United Kingdom, or by any Mayor, Magistrate, Justice of the Peace, Minister of Religion, Barrister-at-Law, Physician, Surgeon, Solicitor, or Notary resident in the United Kingdom. The applicant's Certificate of Birth may also be required in certain cases.
(2) In the case of children under the age of 14 years requiring a separate Passport, upon produc-

tion of a Declaration made by the child's parent or guardian, in a Form (B) to be obtained upon application to the Foreign Office.

(3) In the case of persons naturalised in any of the British self-governing Colonies, upon production of a Recommendation from the High Commissioner or Agent-General in London of the State concerned; and in the case of natives of British India, and persons naturalised therein, upon production of a Letter of Recommendation from the India Office. Persons naturalised or ordinarily resident in any of the Crown Colonies must obtain a Letter of Recommendation from the Colonial Office.

5. If the applicant for a Passport be a Naturalised British subject, the Certificate of Naturalisation must be forwarded to the Foreign Office with the Declaration or Letter of Recommendation. Naturalised British subjects, if resident in London or in the suburbs, must apply personally for their Passports at the Foreign Office; if resident in the country, the Passport will be sent, and the Certificate of Naturalisation returned, to the person who may have verified the Declaration, for delivery to the applicant.

Naturalised British subjects will be described as such in their Passports, which will be issued subject to the necessary qualifications.

6. Foreign Office Passports are not available beyond five years from the date of issue. Fresh Passports must then be obtained.

7. A Passport cannot be issued by the Foreign Office, or by an Agent at an outport, on behalf of a person already abroad; such persons should apply for one to the nearest British Mission or Consulate. Passports

must not be sent out of the United Kingdom by post.

8. Travellers who intend to visit the Russian Empire, the Turkish Dominions, the Kingdom of Rumania, Persia, Colombia, Venezuela, Hayti, or Eritrea, in the course of their travels, must not leave the United Kingdom without having had their Passports *visés* either at the **Russian** Consulate-General, 30, Bedford Square, W.C.; the Consulate-General of the **Sublime Porte**, 7, Union Court, Old Broad Street, E.C.; the **Rumanian** Consulate-General, 3, Mincing Lane, E.C.; the **Persian** Consulate-General, 82, Victoria Street, S.W.; the **Colombian** Consulate-General, Friars House, New Broad Street, E.C.; the **Venezuelan** Consulate, Finsbury Pavement House, Finsbury Pavement, E.C.; the **Haytian** Consulate, 32, Fenchurch Street, E.C.; or the **Italian** Consulate-General (for **Eritrea**), 44, Finsbury Square, E.C., respectively, or at one of the other Consulates of those States in the United Kingdom.

Travellers about to proceed to any other country need not obtain the *visa* of the Diplomatic or Consular Agents of such country.

FOREIGN OFFICE, *February* **14, 1907.**

N.B.—A statement of the requirements of foreign countries with regard to Passports may be obtained upon application to "The Passport Office, Foreign Office, London, S.W."

Applicants, and persons recommending them, are warned that should any of the statements contained in their respective declarations prove to be untrue, they will render themselves liable to prosecution.

Note.—Prospective travellers in Russian Central Asia must apply to their diplomatic representatives at Petrograd to obtain permission.

CALENDARS.

The Julian Calendar, arranged by Julius Caesar, assigns 365 days 6 hours to the year, making it 11 minutes 14 seconds too long. This was rectified by the Gregorian calendar, promulgated by Pope Gregory XIII. in February 1582, and adopted in England in September 1752, when 11 days (the 4th to 14th inclusive) were struck off that month to rectify the previous excess. This, with the subsequently accrued error, constitutes the difference of 13 days between "old style," as retained in Greece and Russia, and "new style," as generally used. The date 5508 B.C. is taken as the starting-point, "Annus Mundi," in place of 4004 of Archbishop Usher's chronology.

The Hebrew calendar, partly lunar, has "ordinary" years of 354 or 355 days, and "embolismic" years of 13 lunar months, 383, 384, or 385 days; seven "embolismic" years being necessary in every cycle of 19 years. The starting-point is 3761 B.C.

The Mohammedan calendar is wholly lunar, 354 or 355 days, the average being 354 days, 8 hours, 48 minutes. This brings the new year round to the same point every 336 years. It dates from the Hegira, 16th July A.D. 662.

Dates of the Different Calendars.

Julian period, 6627.

Gregorian (new style), 1914.

Greek and Russian, old style, A.D. 1914; A.M. 7422.

The year 1911 old style commenced January 13th, 1911 new style.

Hebrew. The year 5674 commenced October 1st, 1913 and ended September 20th, 1914.

Mohammedan. The year 1332 commenced November 30th, 1913 and ended November 18th, 1914.

The Hebrew and Mohammedan day commences at sunset of the previous evening.

SOLAR TIME IN VARIOUS PARTS OF THE WORLD AS COMPARED WITH GREENWICH AT 12 O'CLOCK NOON.

Place	Time.	Place.	Time.
Aden .	3.0 p.m.	Odessa . .	2.2 p.m.
Anapa . .	2.29 ,,	Oil City (Pa.) .	6.38 a.m.
Archangel . .	2.42 ,,	Oklahoma . .	5.30 ,,
Astrakhan . .	3.12 ,,	Paris . .	12.9 p.m.
Baku . .	3.19 ,,	Panama . .	6.42 a.m.
Barbados . .	8.10 a.m.	Petrograd . .	2.1 p.m.
Batoum . .	2.46 p.m.	Petrovsk . .	3.10 ,,
Berlin . .	12.54 ,,	Pittsburgh . .	6.40 a.m.
Brussels . .	12.17 ,,	Port of Spain .	7.54 ,,
Boryslaw . .	1.34 ,,	Rio de Janeiro .	9.8 ,,
Bucharest . .	1.44 ,,	Rome . .	12.49 p.m.
Buda-Pest . .	1.16 ,,	Rostov . .	2.38 ,,
Buenos Ayres .	8.7 a.m.	St. John's (New-	
Calcutta . .	5.53 p.m.	foundland) .	8.29 a.m.
Chicago . .	6.10 a.m.	St. Louis . .	5.59 ,,
Cleveland . .	6.34 ,,	Sakhalin (Alexan-	
Constantinople .	1.56 p.m.	drovsk) . .	9.28 ,,
Dayton (Ohio) .	6.23 a.m.	Samara . .	3.20 ,,
Drohobycz . .	1.34 p.m.	San Francisco .	3.52 a.m.
Ekaterinodar .	2.36 ,,	Santa Barbara .	4.2 ,,
Gibraltar . .	11.39 a.m.	Shanghai . .	8.5 p.m.
Gurieff . .	3.28 p.m.	Stryj . .	1.35 ,,
Indianapolis .	6.15 a.m.	Suez . .	2.10 ,,
Jaworow .	1.34 p.m.	Taltal . .	7.38 a.m.
Kertch .	2.26 ,,	Taman . .	2.28 p.m.
Krasnovodsk .	3.32 ,,	Tampico . .	5.28 a.m.
Lemberg . .	1.36 ,,	Tcheleken . .	3.33 p.m.
Lima (Ohio) .	6.24 a.m.	Tokio . .	9.18 ,,
Los Angeles .	4.7 ,,	Toronto . .	6.42 a.m.
Louisville (Ky.) .	6.17 ,,	Tiflis . .	2.55 p.m.
Madrid . .	11.46 p.m.	Temriuk . .	2.29 ,,
Maikop . .	2.40 ,,	Tustanowice .	1.34 ,,
Marietta (Ohio) .	6.4 a.m.	Uralsk . .	3.25 ,,
Mexico City .	5.24 ,,	Valparaiso . .	7.14 a.m.
Moscow . .	2.30 p.m.	Vera Cruz . .	5.35 ,,
New Orleans .	6.0 a.m.	Vienna . .	1.5 p.m.
New York .	7.4 ,,	Washington .	6.52 a.m.
Novorossisk .	2.31 p.m.	Wellington .	11.38 p.m.

STANDARD TIME.

For railway and other purposes an arbitrary time known as Standard Time has been adopted in many countries, some of which are given below.

Country.	Central Meridian.	Fast or slow of Greenwich Time.
Mid-European . .	15° E.	1h. fast.
Eastern European .	30° ,,	2h. ,,
Egypt . .	30° ,,	2h. ,,
India . . .	82½° ,,	5½h. ,,
Calcutta . .	90° ,,	6h. ,,
Burma . .	97½° ,,	6½h. ,,
Borneo . .	120° ,,	8h. ,,
New Zealand . .	172½° ,,	11½h. ,,
America—		
Atlantic . .	60° W.	4h. slow.
Eastern . .	75° ,,	5h. ,,
Central . .	90° ,,	6h. ,,
Mountain . .	105° ,,	7h. ,,
Pacific . .	120° ,,	8h. ,,

France, Spain, and Belgium have adopted Greenwich time.

Belgium and Italy have adopted the 24-hour system.

EQUIVALENTS OF FOREIGN MONIES.

		s. d. Approx.	£1 Equals.
Argentina.	Peso (of 100 centavos), gold	4 0$\frac{1}{4}$	5·00
	,, ,, ,, paper	1 9	11·45
Austria-Hungary.	Krone (of 100 heller).	0 10	24·00
Belgium.	Franc (of 100 centimes).	0 9$\frac{1}{2}$	25·30
Bolivia.	Peso (of 100 centavos).	2 0	10·00
Brazil.	Milreis (1000 reis).	1 3	18·00
Bulgaria.	Leva (of 100 stotinki).	0 9$\frac{1}{2}$	25·25
Burma.	See India.		
Canada.	Dollar (of 100 cents).	4 2	4·80
Ceylon.	Rupee (of 100 cents).	1 4	15·00
Chile.	Peso (of 100 centavos), gold	1 6	13·30
	,, ,, ,, paper	0 10	21·80
China.	Tael (of 100 cents).	2 10	7·00
Colombia.	Peso (of 100 centavos), gold	4 0	5·00
	,, ,, ,, paper	0 0$\frac{1}{2}$	500·00
Cuba.	Dollar (of 100 cents).	4 2	4·86
Denmark.	Kroner (of 100 öre).	1 1$\frac{1}{2}$	18·18
Egypt.	Piastre (10 millièmes). 100 piastres = 1 Egyptian £.	0 2$\frac{1}{2}$	97·00
France.	Franc (of 100 centimes).	0 9$\frac{1}{2}$	25·30
Germany.	Mark (100 pfennig).	1 0	20·50
Greece.	Drachma (100 lepta).	0 9$\frac{1}{2}$	25·22
Holland.	Gulden (100 cents).	1 8	12·08
India.	Rupee (16 annas).	1 4	15·00
Italy.	Lira (100 centesimi).	0 9$\frac{1}{2}$	25·47
Japan.	Yen (100 sen).	2 0	10·00
Mexico.	Dollar or Peso (of 100 centavos).	2 0	10·00
Newfoundland.	Dollar (100 cents).	4 2	4·80
Norway.	Kroner (100 öre).	1 1$\frac{1}{2}$	18·18

EQUIVALENTS OF FOREIGN MONIES—*continued.*

		s.	d.	£1
		Approx.		Equals.
Peru.	Sol (10 dineros). 10 solis = 1 libra (£1).	2	0	10·00
Portugal.	Milreis (1000 reis).	4	0	5·00
Rumania.	Ley (100 banis).	0	9½	25·20
Russia.	Rouble (100 kopecks).	2	1	9·45
Servia.	Dinar (100 paras).	0	9½	25·12
Siam.	Tikal (4 salungs).	1	6	13·50
Spain.	Peseta (100 centimos). 5 pesetas = 1 douro.	0	9	27·30
Sweden.	Kroner (100 öre).	1	1½	18·18
Switzerland.	Franc (100 centimes).	0	9½	25·00
Turkey.	Piastre (40 paras). 100 piastres = 1 Turkish £.	0	2¼	109·00
United States.	Dollar (100 cents).	4	2	4·86
Uruguay.	Peso (100 centimos) gold.	4	3½	4·66
Venezuela.	Bolivar (100 centimos).	0	9½	25·25

N.B.—Rates of exchange vary from time to time, but the above values are approximately the averages for the different currencies.

TABLE OF DISTANCES FROM PORT TO PORT.

	Nautical Miles.
Aden to Balik Papan	4697
,, ,, Basra	2030
,, ,, Batavia	3922
,, ,, Batum	2794

Aden to Palembang	4197
,, ,, Singapore	3660
,, ,, Suez	1314
,, ,, Surabaya	4292
Anapa to Constantinople	440
Balik Papan to Singapore	1183
Basra to Bushire	160
Batum to Aberdeen	4050
,, ,, Antwerp	3753
,, ,, Belfast	3677
,, ,, Bombay	4430
,, ,, Bristol	3542
,, ,, Calcutta	6098
,, ,, Cardiff	3535
,, ,, Constantinople	575
,, ,, Cork Harbour	3475
,, ,, Dundee	4010
,, ,, Foochow	8280
,, ,, Glasgow	3757
,, ,, Hankow	9278
,, ,, Hong Kong	7878
,, ,, Ilo Ilo	7717
,, ,, Kertch	319
,, ,, Kobe	9083
,, ,, Liverpool	3652
,, ,, Nagasaki	8873
,, ,, Newport	3527
,, ,, Odessa	570
,, ,, Plymouth	3435
,, ,, Shanghai	8628
,, ,, Singapore	6443
,, ,, Southampton	3513
,, ,, Tyne	3900
,, ,, Vladivostok	9463
,, ,, Yokohama	9343
Colon to London	4097
Constantinople to Gibraltar	1780

TABLE OF DISTANCES FROM PORT TO PORT —*continued.*

	Nautical Miles.
Constantinople to Kustendji (Constanza) .	195
" " Odessa . . .	330
Constanza (see Kustendji) . . .	
Dover to Batum	3620
" " Constantinople . . .	3037
" " Gibraltar	1237
" " Kustendji (Constanza) . .	3232
" " Novorossisk	3498
" " Tyne	287
Fiume to Batum	1710
" " Constantinople . . .	1127
" " Gibraltar	1635
" " Kustendji (Constanza) . .	1322
" " Novorossisk	1588
Gibraltar to Aalburg	1844
" " New Orleans . . .	4815
" " New York	3184
Hamburg to Batum	4007
" " Constantinople . . .	3424
" " Dover	387
" " Gibraltar	1624
" " Kustendji (Constanza) . .	3619
" " Novorossisk . . .	3885
" " Tyne	416
Karagel (Island of Tcheleken) to Baku .	200
" " " Krasnovodsk	65
" " " 12 foot soundings (Volga).	500
Kertch to Novorossisk	85
" " Odessa	363
Kustendji (Constanza) to Antwerp . .	3365
" " " Batum . .	578
" " " Belfast . .	3295

Kustendji (Constanza) to Christiania	3864
,, ,, ,, Flushing	3319
,, ,, ,, Gibraltar	1995
,, ,, ,, Hull	3444
,, ,, ,, Kertch	362
,, ,, ,, Marseilles	1576
,, ,, ,, Novorossisk	395
Lisbon to Batum	2686
,, ,, Constantinople	2103
,, ,, Gibraltar	303
Lobitos to Panama	800
,, ,, San Francisco	3450
,, ,, Taltal	1400
London to Aden	4676
,, ,, Alexandria	3130
,, ,, Algiers	1750
,, ,, Archangel (Russia), White Sea	2050
,, ,, Baltimore	3543
,, ,, Barbados	3810
,, ,, Batum	3702
,, ,, Bushire	6468
,, ,, Constantinople	3117
,, ,, Dardanelles	2973
,, ,, Galatz	3461
,, ,, Gibraltar	1326
,, ,, Hamburg	434
,, ,, Kustendji (Constanza)	3315
,, ,, New Orleans	4780
,, ,, New York	3260
,, ,, Novorossisk	3582
,, ,, Odessa	3459
,, ,, Poti	3702
,, ,, San Francisco	13,808
,, ,, St. John's (Newfoundland)	2202
,, ,, Tampico	5076
,, ,, Vera Cruz	5070
Malta to Batum	1414

TABLE OF DISTANCES FROM PORT TO PORT —*continued.*

	Nautical Miles.
Malta to Constantinople	831
,, ,, Gibraltar	992
,, ,, Port Said	961
New York to Constantinople	4984
,, ,, Genoa	4039
,, ,, Marseilles	3871
,, ,, New Orleans	1700
Novorossisk to Batum	252
,, ,, Gibraltar	2261
,, ,, Naples	1439
,, ,, Rouen	3482
,, ,, Tyne	3785
,, ,, Vallö	4462
Odessa to Constantinople	342
,, ,, Gibraltar	2142
,, ,, Kustendji (Constanza)	177
,, ,, Novorossisk	360
Palembang to Singapore	342
,, ,, Suez	5500
Port Said to Batum	1393
,, ,, Constantinople	810
,, ,, Gibraltar	1930
,, ,, Novorossisk	1271
Queenstown to New York	2799
Rotterdam to Batum	3752
,, ,, Constantinople	3169
,, ,, Gibraltar	1369
,, ,, Tyne	286
San Francisco to Acapulco	1850
,, ,, Panama	377
,, ,, Taltal	4850
Singapore to Adelaide	3504
,, ,, Calcutta	1748

Singapore to Durban	4898
,, ,, Hong Kong	1435
,, ,, Melbourne	3804
,, ,, Nagasaki	2430
,, ,, Shanghai	2185
,, ,, Sydney	4279
,, ,, Vladivostok	3020
,, ,, Yokohama	2900
Tampico to Galveston	495
,, ,, Vera Cruz	240
Vera Cruz to Liverpool	4910
Zanzibar to Batum	4503
,, ,, Singapore	4068

EXAMPLE OF AN AGREEMENT BETWEEN AN OIL COMPANY AND A DRILLER, TOOL-DRESSER, CHIEF BLACKSMITH, Etc.

The following contract can be varied to suit most requirements.

AN AGREEMENT made this .... one thousand nine hundred and .... between ...., having its Registered Office at................................, in the City of London (hereinafter called "the Company") of the one part, and .... (hereinafter called "the said employee") of the other part.

Whereby it is agreed by and between the said parties hereto as follows :—

1. Subject as hereinafter mentioned the said employee shall, as from the date of his arrival in ...., and thenceforth during the term of one year, determinable as hereinafter mentioned, act as and be a .... for the Company, and in that

capacity he shall well and faithfully render the following services, and perform the following duties to and for the Company, that is to say :—

(*a*) On such date as the Company shall direct he shall leave for .... and proceed with all expedition by such route, by such means, and in such manner as the Company may direct, to ....

(*b*) He shall on his arrival in .... and thenceforth during his engagement act as a .... for the Company in ...., and in that capacity do all such work, and make all such journeys as he may from time to time be directed to do by the Company or by the General Manager for the time being, or by any other person or firm duly authorised in that behalf by the Company.

(*c*) At all times during the continuance of his engagement he shall in all respects conduct himself with sobriety, and shall be respectful to his superiors in the employment of the Company, and shall implicitly and promptly obey the orders and conform to the directions from time to time given to him by the Company or by its General Manager for the time being, or by any other person or firm duly authorised by the Company in that behalf.

(*d*) At the termination of his engagement he shall give up in proper condition to the General Manager for the time being of the Company, or other its duly authorised agent or agents, all tools, utensils, goods, and effects of the Company which shall then be in his possession or which shall have been entrusted to him,

and all notes, documents, or reports which he may make or obtain in connection with the business of the Company during the continuance of this Agreement and not previously returned by him or properly consumed in the business of the Company.

2. The said employee shall, during the continuance of this Agreement, devote his whole time and attention to the Company's business and affairs, and shall not, directly or indirectly, engage in any other business or trade.

3. The said employee shall not at any time during the continuance of this Agreement, or thereafter, without the written consent or authority of the Company, divulge or make known to any person or persons, or Company or Companies, any knowledge or information which he may receive, obtain, or acquire in relation to the affairs of the Company or its subsidiary Companies, or in relation to the value or conditions or methods of working its or their mining or other properties in ...., or otherwise in relation thereto.

4. The Company shall pay to the said employee during the continuance of his engagement, and so long as he shall duly perform and observe the agreements on his part herein contained, wages after the rate of ....sterling per calendar month payable from the date of his sailing for .... The employee shall not be entitled to wages during the voyage from................ to............... except in respect of any unexpired portion of the notice referred to in Clause 10 hereof. Provided that the said employee shall not be required to work more than............. hours per diem without extra remuneration, such extra remuneration to be fixed by arrangement between the said employee and the Company's General Manager or other duly authorised representative in that behalf.

Provided also that the said employee shall not be required to work on Sundays except at an increase of fifty per centum in the wages payable to him hereunder, calculated according to the number of hours worked by him on Sunday. Should the said employee desire a portion of his wages to be paid in .... the Company, on receiving his written notice to that effect, will so pay such portion as decided, but not exceeding four-fifths of such monthly wages.

5. The Company shall pay the travelling expenses of the said employee on his journey to .... and back again; that is to say, ... class fare on steamship and ...... class fare on railways.

6. The Company shall during such time as the said employee shall be in................ and engaged under this Agreement, pay all his reasonable expenses for lodgings and all necessary furniture, including bedding, rations, and medicine, but not alcoholic liquor.

7. Prior to his leaving................to take up his duties in .... hereunder the Company shall advance to the said employee the sum of £........ towards the expenses of his outfit, such advance to be repaid to the Company by the sum of £.......... being deducted from the wages of the said employee each month until the whole sum shall have been refunded.

8. If the said employee shall at any time during the continuance of this Agreement absent himself from his duties hereunder without leave duly given, then the wages payable to him hereunder shall cease to be payable during the time when he shall be so absent.

9. In the event of the said employee being rendered incapable for a period exceeding one month of performing his duties from ill-health or by accident or from any other cause, then the Company may, either by one month's notice in writing given to the said employee, determine his engagement hereunder, or may at their option place the said employee on half pay for such time

as he shall remain so incapable as aforesaid. But if such incapacity is attributable to any imprudence, insobriety, misconduct, or wilful disobedience, or if the said employee shall directly refuse to obey the commands of, or be guilty of any flagrant misdemeanour towards the Company or its General Manager, or any other person duly authorised by it or him in that behalf, then the Company, its General Manager, or any other duly authorised person may at once determine this Agreement without notice, and then in such cases the said employee shall not be entitled to the expenses of his return journey to........, nor to any wages as from the date of the determination of this Agreement under this present provision. Except as herein is otherwise expressly provided, the said employee shall not, after the determination of his engagement and the payment of his wages up to the expiration of the notice referred to in Clause 10 hereof whether such notice shall expire whilst the employee is in .... or whilst he may be on his way back to..............as the case may be, be entitled to receive from the Company any benefit or remuneration whatever.

9A. In lieu of food and medicine referred to in the previous clause, the Company shall have the right to pay the employee the sum of .... per day.

10. The Company may determine this Agreement at any time upon giving to the said employee one calendar month's notice in writing, or, in lieu thereof, paying one month's wages, and upon the expiration of the period specified in such notice, or payment of one month's wages in lieu thereof, as aforesaid, the said employee shall cease to be in the employ of the Company.

11. Any notice, order, or direction signed by the Agents or Agent or General Manager of the Company for the time being, and delivered to the said employee, or posted to him at his last known address, shall be deemed sufficiently given to him by the Company for all the purposes of this Agreement, and shall be deemed to be served in due course

of post, and in proving such service it shall be sufficient to prove that the same was properly addressed and posted.

As WITNESS the hand of..........................
on behalf of the Company, and the hand of the said employee, the day and year first above written.

Signed by the said..................
....
in the presence of ....
....
....

Signed by the said..................
....
in the presence of ....
....
....

TO FIND THE MERIDIAN BY A WATCH.

When the sun is visible, the position of the meridian line can be approximately determined in the following manner by a watch set to local time : Turn the face of the watch to the sun in such a way that the hour-hand shall point to the sun, or, in other words, so that the hour-hand is directly over its shadow. Midway between the place of the hour-hand and XII will be the south point in north latitude, and the opposite point on the dial will be the north point. In south latitude the reverse of this would be the case, while in the tropics the position of the north and south points will depend on whether the sun is north or south of the observer. When the sun is near the zenith, the shadow of an upright rod may be used, the hour-hand being brought into line with it.

ANEROID BAROMETER.

The aneroid barometer serves to indicate the altitude of any point, if the barometric pressure at sea level at the time of observation is known. It may also be used,

without reference to the pressure at sea level, to find the difference in altitude between different points.

Aneroids are made with an inner scale, corresponding to that of the mercury barometer, and an outer scale attached to a movable rim (so that its zero may be adjusted as necessary) which indicates altitudes in feet. Readings taken at intervals during a journey indicate differences in height fairly accurately, provided that no appreciable change in pressure at any point has occurred within the period over which the observations have extended. If the path be retraced, and check readings be taken, any necessary corrections for alterations other than those due to altitude may be made.

Aneroids are constructed for various special requirements, and in selecting an instrument for any particular survey the nature of the work to be undertaken, viz. the range of altitudes to be encountered and the degree of precision of reading required, must be taken into consideration.

Changes of temperature affect the readings of an aneroid. Many instruments have a thermometer attached, with a view to the corrections for temperature being made. Others are compensated so as to be unaffected by changes of temperature.

CASPIAN SEA.

This sea is 85 feet below the level of the Black Sea.

ARTESIAN WELLS.

Where porous beds enclosed between impervious strata are curved into basin form, and charged with water at the margin, a well sunk in the interior will find water, rising to or above the surface, according to the hydrostatic pressure due to the higher level of the margin of the basin. Such a well is known as artesian, from the old province of Artois, in France, where they have long been in use.

CARDINAL NUMBERS

English.	French.	German.	Spanish.
One.	Un.	Ein.	Uno.
Two.	Deux.	Zwei.	Dos.
Three.	Trois.	Drei.	Tres.
Four.	Quatre.	Vier.	Cuatro.
Five.	Cinq.	Fünf.	Cinco.
Six.	Six.	Sechs.	Seis.
Seven.	Sept.	Sieben.	Siete.
Eight.	Huit.	Acht.	Ocho.
Nine.	Neuf.	Neun.	Nueve.
Ten.	Dix.	Zehn.	Diez.
Eleven.	Onze.	Elf.	Once.
Twelve.	Douze.	Zwölf.	Doce.
Thirteen.	Treize.	Dreizehn.	Trece.
Fourteen.	Quatorze.	Vierzehn.	Catorce.
Fifteen.	Quinze.	Fünfzehn.	Quince.
Sixteen.	Seize.	Sechzehn.	Diez y seis.
Seventeen.	Dix-sept.	Siebzehn.	Diez y siete.
Eighteen.	Dix-huit.	Achtzehn.	Diez y ocho.
Nineteen.	Dix-neuf.	Neunzehn.	Diez y neuve.
Twenty.	Vingt.	Zwanzig.	Veinte.
Twenty-one.	Vingt-et-un.	Ein und zwanzig.	Veinte y uno.
Thirty.	Trente.	Dreissig.	Treinta.
Forty.	Quarante.	Vierzig.	Cuarenta.
Fifty.	Cinquante.	Fünfzig.	Cincuenta.
Sixty.	Soixante.	Sechzig.	Sesenta.
Seventy.	Soixante-dix.	Siebzig.	Setenta.
Eighty.	Quatre-vingts.	Achtzig.	Ochenta.
Ninety.	Quatre-vingt-dix.	Neunzig.	Noventa.
Hundred.	Cent.	Hundert.	Ciento.
Thousand.	Mille.	Tausend.	Mil.

FROM 1 to 1000.

Italian.	Rumanian.	Russian.	Polish.
Uno.	Un.	Odin, odna.	Jeden, jedna, jedno.
Due.	Doi.	Dva, dvye.	Dwa, dwie, dwoje.
Tre.	Treĭ.	Tri.	Trzy.
Quattro.	Patru.	Tchetire.	Cztéry.
Cinque.	Cinci.	Pyat.	Pieć.
Sei.	Sése.	Shest.	Sześć.
Sette.	Sépte.	Sem.	Siedm.
Otto.	Opt.	Vosem.	Osm.
Nove.	Noua.	Devyat.	Dziewieć.
Dieci.	Déce.	Desyat.	Dziesieć.
Undici.	Un spredece.	Odinnadtzat.	Jedenascie.
Dodici.	Dou spredece.	Dvyenadtzat.	Dwanascie.
Tredici.	Treĭ spredece.	Trinadtzat.	Trzynascie.
Quattordici.	Patru spredece.	Tchetirnadtzat.	Czternascie.
Quindici.	Cinci spredece.	Pyatnadtzat.	Pietnascie.
Sedici.	Sése spredece.	Shestnadtzat.	Szesnascie.
Diciasette.	Sépte spredece.	Semnadtzat.	Siedemnascie.
Diciotto.	Opt spredece.	Vosemnadtzat.	Osiemnascie.
Diciannove.	Nou spredece.	Devyatnadtzat.	Dwiewietnascie.
Venti.	Dou deci.	Dvadtzat.	Dwadziescia.
Vent'uno.	Dou deci uno.	Dvadtzat odin.	Dwadziesciajeden.
Trenta.	Treĭ deci.	Tridtzat.	Trzydziesci.
Quaranta.	Patru deci.	Sorok.	Czterdiesci.
Cinquanta.	Cinci deci.	Pyatdesyat.	Piecdziesiat.
Sessanta.	Sése deci.	Shestdesyat.	Szescdziesiat.
Settanta.	Sépte deci.	Semdesyat.	Siedemdziesiat.
Ottanta.	Opt deci.	Vosemdesyat.	Osiemdziesiat.
Novanta.	Nou deci.	Devyanosto.	Dziewiecdziesiat.
Cento.	O sutá.	Sto.	Sto.
Mille.	O mie.	Tisyatcha.	Tysiać.

DAYS OF THE WEEK IN EIGHT LANGUAGES.

English.	French.	German.	Spanish.	Italian.	Rumanian.	Russian.	Polish.
Monday.	Lundi.	Montag.	Lunes.	Lunedí.	Luní.	Ponedelnik.	Poniedzialek.
Tuesday.	Mardi.	Dienstag.	Mártes.	Martedí.	Martí.	Vtornik.	Wtorek.
Wednesday.	Mercredi.	Mittwoch.	Miércoles.	Mercoledí.	Mercurí.	Sereda.	Srzoda.
Thursday.	Jeudi.	Donnerstag.	Juéves.	Giovedí.	Joí.	Chetverg.	Czwartek.
Friday.	Vendredi.	Freitag.	Viérnes.	Venerdí.	Vinerí.	Pyatnitsa.	Piatek.
Saturday.	Samedi.	Samstag (Sonnabend).	Sábado.	Sabato.	Simbatâ.	Subbota	Sobota.
Sunday.	Dimanche.	Sonntag.	Domingo.	Domència.	Duminica.	Voskresenye.	Niedziela.

NAMES OF THE MONTHS IN EIGHT LANGUAGES.

English.	French.	German.	Spanish.	Italian.	Rumanian.	Russian.	Polish.
January.	Janvier.	Januar.	Enero.	Gennaio.	Ianuariŭ.	Yanvar.	Styczeń.
February.	Février.	Februar.	Febrero.	Febbraio.	Februariŭ.	Phevral.	Luty.
March.	Mars.	März.	Marzo.	Marzo.	Marte.	Mart.	Marzeć.
April.	Avril.	April.	Abril.	Aprile.	Aprile.	Apriel.	Kwiecien.
May.	Mai.	Mai.	Mayo.	Maggio.	Maiŭ.	Mai.	Maj.
June.	Juin.	Juni.	Junio.	Giugno.	Iuniŭ.	Iyun.	Czerwiec.
July.	Juillet.	Juli.	Julio.	Iuglio.	Iuliŭ.	Iyul.	Lipiec.
August.	Août.	August.	Agosto.	Agosto.	Augustŭ.	August.	Sierpien.
September.	Septembre.	September.	Setiembre.	Settembre.	Septembre.	Sentyabr.	Wrzesien.
October.	Octobre.	October.	Octubre.	Ottobre.	Octobre.	Oktyabr.	Pardziernik.
November.	Novembre.	November.	Noviembre.	Novembre.	Novembre.	Noyabr.	Listopad.
December.	Décembre.	December.	Diciembre.	Decembre.	Decembre.	Dekabr.	Grudzien.

NAMES FOR BITUMENS IN VARIOUS LANGUAGES.

Language.	Asphalt.	Mineral Oil.
Burmese.	..	Yenan.
Danish.	*See* Scandinavian.	
Dutch.	Asphalt.	Aardolie.
	Jodenlijm.	Petroleum.
	..	Stenol.
French.	Asphalte.	Huile minérale.
	Goudron minérale.	Pétrole.
German.	Asphalt.	Bergöl.
	Bergtheer.	Erdöl.
	Erdpech.	Petroleum.
	Steinpech.	Steinöl.
Greek.	Asphaltos.	Petrelaion.
	Katrami or Katrani Pissa.	..
Hungarian.	*See* Magyar.	
Italian.	Asfalto.	Petrolio.
	Bitume.	..
Magyar.	Aszfalt. Földszurok.	Köolaj.
	Katrany.	Földolaj.
Norwegian.	*See* Scandinavian.	
Persian.	Mumiya.	Naft.
Polish.	Asfalt.	Nafta. Ropa.
	Smola skalni.	Olej skalni.
Portuguese.	Asphalto.	Petroleo.
	Betume.	..
	Pez de terra.	..
Rumanian.	Asfalt. Smólă.	Petroleu.
	Bitum. Pece.	Namesica.
	Pacura. Pĕcură.	Titei.
Russian.	Asphalt.	Gornoe maslo.
	Gornaia smola.	Nepht.
	Kir.	Masut.*
Scandinavian.	Bergbeck, or -beg.	Bergolja.
	Jordbeck, ,,	Petroleum.
	Judebeck, ,,	..
Spanish.	Alquitran.	Petroleo.
	Asfalto.	Aceite minerale.
	Betun.	..
	Brea. Pega minerale.	..
Spanish America.	Chapo and Chapopote.	..
	Pez de tierra.	..
Swedish.	*See* Scandinavian.	
Turkish.	Zift.	Ma'den-hefti.
		Ghaz.

* *Masut* is crude oil which has lost its more volatile constituents by evaporation.

Part IX.

STATISTICS.

STATISTICS.

THE figures giving the production of crude petroleum, asphalt, ozokerite, etc., have been mainly taken from statistical data published in the annual Bluebook *Mines and Quarries*, compiled by the Chief Inspector of Mines and issued by the Home Office, and from *Mineral Resources of the United States*, issued by the Department of the Interior, Washington. The Colonial and Foreign statistics given in *Mines and Quarries* are, as a rule, two years old when published, and it is practically impossible to obtain complete trustworthy records of the production of any year, until the end of the following year, or in some instances even late in the year after that. In the majority of cases the following tables give the output of various countries only up to the end of 1911, but in some instances for 1912 also. Figures for the years prior to 1900 will be found in *Petroleum*, Redwood (3rd edition, 1913).

[TABLE.

PRODUCTION OF CRUDE OIL.

UNITED STATES OF AMERICA.

QUANTITY OF PETROLEUM PRODUCED.

Year.	Quantity. Barrels of 42 American Gallons.
1900 . . .	63,620,529
1901 . . .	69,389,194
1902 . . .	88,766,916
1903 . . .	100,461,337
1904 . . .	117,080,960
1905 . . .	134,717,580
1906 . . .	126,493,936
1907 . . .	166,095,335
1908 . . .	178,527,355
1909 . . .	183,170,874
1910 . . .	209,557,248
1911 . . .	220,449,391
1912 . . .	222,113,218

PRODUCTION AND VALUE OF CRUDE OIL BY STATES.

State.	1909. Quantity in Barrels of 42 U.S.A.Gallons.	1909. Value.	1909. Average price per Barrel.	1910. Quantity in Barrels of 42 U.S.A.Gallons.	1910. Value.	1910. Average price per Barrel.
		$	$		$	$
California.	55,471,601	30,756,713	0·554	73,010,560	35,749,473	0·490
Colorado.	310,861	318,162	1·023	239,794	243,402	1·015
Illinois.	30,898,339	19,788,864	0·640	33,143,362	19,669,383	0·593
Indiana.	2,296,086	1,997,610	0·870	2,159,725	1,568,475	0·726
Kansas.	1,263,764	491,633	0·389	1,128,668	444,763	0·394
Kentucky.	639,016	518,299	0·811	468,774	324,684	0·693
Louisiana.	3,059,531	2,022,449	0·661	6,841,395	3,574,069	0·522
Michigan. Missouri.	5,750	7,830	1·362	3,615	4,794	1·326
New York.	1,134,897	1,878,217	1·655	1,053,838	1,414,668	1·342
Ohio.	10,632,793	13,225,377	1·244	9,916,370	10,651,568	1·074
Oklahoma.	47,859,218	17,428,990	0·364	52,028,718	19,922,660	0·383
Pennsylvania.	9,299,403	15,424,554	1·659	8,794,662	11,908,914	1·354
Texas.	9,534,467	6,793,050	0·712	8,899,266	6,605,755	0·742
Utah. Wyoming.	20,056	34,456	1·718	115,430	93,536	0·810
West Virginia.	10,745,092	17,642,283	1·642	11,753,071	15,723,544	1·338
Total.	183,170,874	128,328,487	0·701	209,557,248	127,899,688	0·610

PRODUCTION AND VALUE OF CRUDE OIL BY STATES—*continued.*

State.	1911.			1912.		
	Quantity in Barrels of 42 U.S.A. Gallons.	Value.	Average price per Barrel.	Quantity in Barrels of 42 U.S.A. Gallons.	Value.	Average price per Barrel.
		$	$		$	$
California.	81,134,391	38,719,080	0·477	86,450,767	39,213,588	0·454
Colorado.	226,926	228,104	1·005	206,052	199,661	0·973
Illinois.	31,317,038	19,734,339	0·630	28,601,308	24,332,605	0·851
Indiana.	1,695,289	1,228,835	0·740	970,009	885,975	0·913
Kansas.	1,278,819	608,756	0·476	1,592,796	1,095,698	0·688
Kentucky.	472,458	328,614	0·696	484,368	424,842	0·877
Louisiana.	10,720,420	5,668,814	0·529	9,263,439	7,023,827	0·758
Michigan. } Missouri. }	7,995	7,995	1·000	*	*	..
				..	..	..
New York.	952,515	1,248,950	1·311	874,128	1,401,880	1·604
Ohio.	8,817,112	9,479,542	1·075	8,969,007†	12,085,998†	1·347
Oklahoma.	56,069,637	26,451,767	0·472	51,427,071	34,672,604	0·674
Pennsylvania.	8,248,158	10,894,074	1·321	7,837,948	12,886,752	1·644
Texas.	9,526,474	6,554,552	0·688	11,735,057	8,852,713	0·754
Utah. } Wyoming. }	186,695	124,037	0·664	1,572,306	798,470	0·507
West Virginia.	9,795,464	12,767,293	1·303	12,128,962	19,927,721	1·643
Total.	220,449,391	134,044,752	0·608	222,113,218	163,802,334	0·737

* Included in Ohio. † Includes Michigan.

RANK OF PETROLEUM-PRODUCING STATES IN 1911 AND 1912.

1911. State.	1911. Percentage of Total.	1912. State.	1912. Percentage of Total.
California	36·80	California	38·92
Oklahoma	25·44	Oklahoma	23·15
Illinois	14·21	Illinois	12·88
Louisiana	4·86	West Virginia	5·46
West Virginia	4·44	Texas	5·28
Texas	4·32	Louisiana	4·17
Ohio	4·00	Ohio*	4·04
Pennsylvania	3·74	Pennsylvania	3·53
Indiana	0·77	Kansas	0·72
Kansas	0·58	Wyoming	0·71
New York	0·43	Indiana	0·44
Kentucky	0·22	New York	0·39
Colorado	0·10	Kentucky	0·22
Wyoming, Missouri, Utah, Michigan	0·09	Colorado	0·09
		Michigan†	..
	100·00		100·00

* Includes Michigan. † Included in Ohio.

The table given below shows the average initial production per well in barrels in various States.

AVERAGE DAILY INITIAL PRODUCTION PER WELL IN BARRELS OF 42 U.S.A. GALLONS.

State.	1906.	1907.	1908.	1909.	1910.
Pennsylvania and New York.	4·48	3·77	2·91	3·18	3·99
Kentucky and Tennessee.	23·1	17·5	18·1	23·8	11·8
Lima (Ohio) .	10·4	10·2	11·4	10·3	13·5
Indiana . .	15·0	10·2	10·2	17·6	30·5
Illinois . .	40·5	32·7	26·2	34·6	55·5
Kansas . .	15·7	13·0	16·1	19·0	22·3
Oklahoma .	71·1	131·7	87·1	75·3	71·1
Northern Texas .	..	10·8	19·8	10·8	15·6
Coastal Texas .	112·1	126·6	166·1	89·7	173·5
Louisiana .	252·0	740·0	676·4	210·3	994·7

WELL RECORD IN THE UNITED STATES IN 1911.

Field.	Wells completed.				Initial daily Production, in Barrels.	
	Oil.	Gas.	Dry.	Total.	Total.	Average per Well.
Appalachian	2978	976	1060	5,014	28,100	9·44
Pennsylvania and New York	1491	219	297	2,007	4,912	3·29
Central and South-Eastern Ohio	765	403	512	1,680	10,923	14·28
West Virginia	622	351	218	1,191	10,443	16·79
Kentucky	100	3	33	136	1,822	18·22
Lima-Indiana	554	23	67	644	7,477	13·50
Lima, Ohio	480	15	32	527	6,381	13·29
Indiana	74	8	35	117	1,096	14·81
Illinois	1061	41	263	1,365	66,851	63·01
Mid-Continent	3796	490	686	4,972	453,907	119·58
Kansas	172	150	96	418	3,271	19·01
Oklahoma	3294	304	489	4,087	262,333	79·64
Northern Texas	84	4	38	126	19,180	228·33
Caddo *	246	32	63	341	169,123	687·49
Gulf	415	50	149	614	106,885	257·55
Coastal Texas	352	33	117	502	32,740	93·01
Coastal Louisiana	63	17	32	112	74,145	1176·90
California	970	..	104	1,074	..	..
Colorado	14	..	18	32	..	..
Wyoming and Utah	37	..	16	53	..	..
	9825	1580	2363	13,768	..	..

* Includes Marion County, Texas.

WELL RECORD IN THE UNITED STATES IN 1912.

Field.	Wells completed.				Initial daily Production, in Barrels.	
	Oil.	Gas.	Dry.	Total.	Total.	Average per Well.
Appalachian	3,931	1016	1077	6,024	142,711	36·3
Pennsylvania and New York	1,911	239	322	2,472	6,771	3·5
Central and South-Eastern Ohio	846	411	460	1,717	24,193	28·6
West Virginia	1,062	361	234	1,657	109,804	103·4
Kentucky	112	5	61	178	1,943	17·3
Lima-Indiana	547	18	75	640	8,312	15·2
Lima, Ohio	482	14	55	551	7,229	15·0
Indiana	65	4	20	89	1,083	16·7
Illinois	980	23	257	1,260	65,686	67·0
Mid-Continent	5,786	754	1189	7,729	348,442	60·2
Kansas	536	253	160	949	7,245	13·5
Oklahoma	4,712	438	843	5,993	228,886	48·6
Northern Texas	299	11	124	434	28,213	94·3
Caddo, La.	239	52	62	353	84,098	351·9
Gulf	412	..	134	546	58,602	142·2
Coastal Texas	353	..	109	462	33,082	93·7
Coastal Louisiana	59	..	25	84	25,520	432·5
California	776	..	71	847	..	..
Colorado	15	..	13	28	..	..
Wyoming and Utah	59	..	25	84	..	..
Michigan	6	..	2	8	..	..
Miscellaneous	..	..	12	12	..	..
Total for 1912	12,512	1811	2855	17,178	..	..
Corresponding total for 1911	9,825	1580	2363	13,768	..	..

CONSUMPTION OF FUEL OIL BY THE RAILROADS OF THE UNITED STATES.

Year.	Quantity consumed in Barrels of 42 U.S.A. Gallons.	Estimated Mileage covered by Oil-burning Engines.	Average Miles per Barrel of Oil consumed.	Length of Line in Miles operated by the use of Fuel Oil.*
1906	15,577,677	..	..	..
1907	18,855,002†	74,079,726	3·93	13,573
1908	16,889,070‡	64,279,509	3·81	15,474
1909	19,939,394§	72,918,118	3·66	17,676
1910	24,586,108‖	89,107,883	3·74	22·709
1911	29,748,845	109,680,976	3·69	30,039
1912	33,605,598	121,393,228	3·61	28,451

* Some of these lines also used coal.
† Includes 5199 barrels used for shop purposes.
‡ Includes 18,188 barrels used for shop purposes.
§ Includes 34,059 barrels used for firing stationary engines and for shop boilers.
‖ Includes 768,762 barrels used for fuel other than for locomotives.

RUSSIA.

Production of Crude Petroleum.

Year.	Baku Field.	Grozni Field.	Maikop Field.	Other Fields.	Total.
	Poods.	Poods.	Poods.	Poods.	Poods.
1900	600,763,812	30,687,948	..	..	631,451,760
1901	671,706,147	34,852,271	..	..	706,558,418
1902	636,831,120	34,072,271	..	..	670,903,391
1903	597,355,061	32,772,271	..	..	630,127,332
1904	615,344,821	39,797,000	..	..	655,141,821
1905	414,762,000	41,328,000	..	..	456,090,000
1906	447,520,000	38,373,603	..	4,721,000*	490,614,603
1907	476,002,000	39,214,612	..	..	515,216,612
1908	465,343,000	52,058,895	..	611,221†	518,013,116
1909	492,500,000	57,033,015	..	..	549,533,015
1910	497,842,212	74,048,358	1,304,800	12,708,290‡	585,903,660
1911	434,310,329	75,189,591	7,933,936	33,876,295§	551,310,151
1912	429,300,000	65,400,000	9,200,000	62,700,000‖	566,600,000

* Produced in Bereki and Tchimion oil-fields.

† Produced in Surakhany.

‡ Includes 10,613,909 poods produced in Surakhany, 1,392,306 poods produced in Sviatoi, 610,500 poods produced in Ferghana, and 91,575 poods produced in Taman.

§ Includes 19,896,524 poods produced in Surakhany, 2,515,363 poods produced in Sviatoi, 10,205,740 poods produced in Tcheleken, and 610,500 poods produced in Ferghana.

‖ Includes 43,900,000 poods produced in Surakhany, 3,300,000 poods produced in Sviatoi, 13,300,000 poods produced in Tcheleken, and 2,200,000 poods produced in Ferghana.

PRODUCTION OF CRUDE PETROLEUM BY PUMPING AND FLOWING WELLS IN THE GROZNI FIELD.

Year.	Pumping.	Flowing.	Total.
	Poods.	Poods.	Poods.
1907 . . .	33,840,762	5,373,850	39,214,612
1908 . . .	37,741,980	14,316,915	52,058,895
1909 . . .	50,997,451	6,035,564	57,033,015
1910 . . .	58,097,733	15,950,625	74,048,358
1911 . . .	71,481,505	3,708,086	75,189,591
1912 . . .	65,319,687	109,920	65,429,607

NUMBER AND CONDITION OF THE WELLS IN THE BAKU FIELD

Condition of Wells.	Balakhani.			Sabuntchi.		
	1910.	1911.	1912.	1910.	1911.	1912.
Completed . .	40	27	60	98	62	111
Producing, Dec. 31st .	762	778	888	915	966	1,118
Trial pumping, Dec. 31st	6	19	9	24	34	29
Drilling, Dec. 31st .	22	24	41	56	68	72
Drilling deeper, Dec. 31st	33	..	16	95	..	25
Cleaning out and repairing	4	10	6	16	24	26
Standing idle . .	393	365	335	629	666	608
Rigs erected, ready for drilling . . .	16	16	24	44	47	60
New wells sunk . .	40	45	79	76	91	119
Length of wells drilled, in feet . . .	62,349	65,751	92,743	144,053	132,475	172,739

FOR THE YEARS ENDED DECEMBER 31st, 1910, 1911, AND 1912.

Romani.			Bibi-Eibat.			Total.		
1910.	1911.	1912.	1910.	1911.	1912.	1910.	1911.	1912.
43	27	39	28	19	17	209	135	227
223	254	282	266	282	300	2,166	2,280	2,588
5	5	1	9	8	13	44	66	52
27	31	33	40	34	37	145	157	183
53	..	12	55	..	19	236	..	72
14	9	15	5	9	11	39	52	58
228	228	220	163	162	158	1,413	1,421	1,321
11	4	6	13	13	20	84	80	52
30	37	33	23	13	21	169	186	110
65,590	60,039	64,134	65,919	54,019	45,255	337,911	312,284	374,871

PARTICULARS OF THE WELLS IN THE GROZNI FIELD.

Year.	Total Number of Wells.	Producing, Dec. 31.	Boring and Deepening, Dec. 31.	Average depth of Wells in Feet.	Total sum of depth, in Feet, of Producing Wells.	Total length, in Feet, of Wells Drilled in the Year.
1907	271	205	45	..	185,346	..
1908	287	172	51	1348·2	203,574	..
1909	320	182	58	1458·1	250,831	82,537
1910	343	234	67	1557	..	87,836
1911	358	195	61	1670	..	72,933
1912	402	..	71	1752	..	18,986

AUSTRIA.

Production of Crude Petroleum in Galicia.*

Year.	Metric Tons.
1900	326,334
1901	452,200
1902	576,060
1903	727,971
1904	827,116
1905	801,796
1906	760,443
1907	1,175,974
1908	1,754,022
1909	2,076,740
1910	1,762,560
1911	1,462,940
1912	1,187,007

* In Galicia and Rumania a tank-car (cisterne) has been commercially adopted as a standard of weight, and is recognised as meaning 10 metric tons of oil. The production of wells is generally given as so many tank-cars per day or month, and sales are also effected on the basis of this unit.

[Table.

PRODUCTION OF PETROLEUM IN GALICIA, IN METRIC TONS.

Field.	1907.	1908.	1909.	1910.	1911.	1912.
East Galicia :						
Tustanowice .	1,011,590	1,318,710	1,706,435	1,404,320	1,105,420	856,440
Boryslaw .		266,910	231,195	209,300	197,320	170,500
Schodnica .	39,650	36,480	34,860	32,860		
Urycz . .	13,510					
Mraznica .	1,490	30,022	28,110	38,170		
Other Fields .	12,230					
West Galicia :						
Potok . .	13,850		11,370	13,010		
Rogi . .	9,033	50,640	9,540	8,200	160,200	160,067
Rowne . .	1,981					
Krosno . .	29,960		20,690	25,200		
Tarnawa-Wielo-pole-Zagorz .	17,390	18,200	6,770	2,700		
Kobylanka, Kryg, Zalawie, Lipinki, Libusza, etc. .	25,290	33,060	27,770	28,800		
Total .	1,175,974	1,754,022	2,076,740	1,762,560	1,462,940	1,187,007

BUKOWINA.

No statistics relating to the small yield of crude petroleum in the Bukowina appear to be available.

EASTERN ARCHIPELAGO.

According to the *Mineral Resources of the United States* for the year 1909, the production of petroleum in Sumatra, Java, and Borneo prior to 1906 was as follows :—

Year.	Sumatra.	Java.	Borneo.	Total.
	Metric Tons.	Metric Tons.	Metric Tons.	Metric Tons.
1900	158,467*	83,867	59,352	301,686
1901	357,665*	88,597	85,554	531,816
1902	186,655	54,455	84,232	325,342
1903	563,988	91,568	105,102	760,658
1904	542,936	110,053	215,109	868,098
1905	513,630	110,711	439,487	1,063,828

* Estimated.

According to information furnished by the Bataafsche Petroleum Maatschappij of The Hague, the aggregate production of crude oil in the Dutch East Indies was as follows :—

Year.	Quantity Tons.
1906	1,331,499
1907	1,330,694
1908	1,254,838
1909	1,413,741
1910	1,435,240
1911	1,624,301

RUMANIA.

Production of Petroleum.*

Year.	Quantity. Metric Tons.	Year.	Quantity. Metric Tons.
1900	250,000	1907	1,129,097
1901	270,000	1908	1,147,727
1902	310,000	1909	1,297,257
1903	384,302	1910	1,352,407
1904	496,888	1911	1,544,847
1905	614,870	1912	1,806,942
1906	887,091		

BRITISH INDIA.

Quantity and Value of Crude Petroleum Produced.

Year.	Quantity.	Value.
	Imperial Gallons.	£.
1900	37,729,211	148,754
1901	50,075,117	204,342
1902	56,607,688	217,816
1903	87,859,069	354,364
1904	118,491,382	473,971
1905	144,798,444	604,204
1906	140,553,122	574,238
1907	152,045,677	610,015
1908	176,646,320	702,009
1909	233,678,087	910,172
1910	214,829,647	835,927
1911	225,792,094	884,398
1912	249,083,518	975,278

* In Galicia and Rumania a tank-car (cisterne) has been commercially adopted as a standard of weight, and is recognised as meaning 10 metric tons of oil. The production of wells is generally given as so many tank-cars per day or month, and sales are also effected on the basis of this unit.

MEXICO.

Quantity (estimated) of Crude Petroleum Produced.

Year.	Quantity. Metric Tons.
1907	133,333
1908	464,188
1909	331,832
1910	444,373
1911	1,873,547
1912	2,207,762

JAPAN.

Production of Crude Petroleum.

Year.	Imperial Gallons.	Quantity in Koku.
1900	30,353,552	767,092
1901	39,025,100	983,000
1902	42,082,600	1,060,000
1903	42,284,105	1,065,116
1904	49,606,579	1,249,536
1905	51,470,494	1,296,486
1906	59,612,051	1,501,563
1907	69,691,920	1,755,464
1908	72,055,539	1,815,001
1909	65,784,329	1,657,036
1910	67,329,215	1,695,950
1911	57,916,742	1,458,860
1912	58,410,888	1,471,307

1 Koku = 39·7 imperial gallons.

FORMOSA.

Production of Crude Petroleum.

Year.	Quantity.	
	Koku.	Imperial Gallons.
1906	4394	174,442
1907	6717*	266,665
1908	7310	290,207
1909	5664	224,861
1910	3208	127,358
1911	1442	57,247
1912	3040	120,688

* Estimated.

PERU.

Production of Petroleum in Peru, in Barrels of 42 U.S.A. Gallons.

Year.	Lobitos.	Negritos.	Zorritos.	Lake Titicaca (Huancane).	Total.
1905	75,000*	335,160	37,720	..	447,880
1906	162,000	330,510	42,419	1,365	536,294
1907	279,000	396,750	65,476	15,000	756,226
1908	319,898	543,750	71,429	76,103*	1,011,180
1909	429,195	740,070	70,750	76,103*	1,316,118
1910	400,080	773,025	107,000	50,000*	1,330,105
1911	391,290	882,698	64,286	30,000	1,368,274
1912	587,048	1,071,000	73,095	15,000*	1,751,143

* Estimated.

GERMAN EMPIRE.

Quantity and Value of Petroleum Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	50,375	186,304
1901	44,095	147,523
1902	49,725	167,550
1903	62,680	216,700
1904	89,620	290,200
1905	78,869	260,350
1906	81,350	251,800
1907	106,379	352,800
1908	141,900	497,100
1909	143,244	505,900
1910	145,168	507,300
1911	142,992	502,250
1912	140,000*	489,514

* Estimated.

CANADA.

Quantity and Value of Crude Petroleum Produced.

Year.	Quantity in Barrels of 35 Imperial Gallons.	Value.
1901	756,679	£252,746
1902	530,624	196,121
1903	486,637	216,283
1904	552,575	202,950
1905	634,095	176,500
1906	569,753	157,064
1907	788,872	217,956
1908	527,987	154,041
1909	420,755	115,382
1910	315,895	80,113
1911	291,096	73,623
1912	243,614	71,770

ITALY.

Quantity and Value of Petroleum Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	1683	19,671
1901	2246	26,842
1902	2633	31,126
1903	2486	29,492
1904	3543	42,132
1905	6122	73,072
1906	7451	89,062
1907	8326	66,532
1908	7088	56,626
1909	5895	47,146
1910	7069	56,552
1911	10,390	58,184
1912	12,000*	..

* Estimated.

HUNGARY.

Quantity and Value of Crude Petroleum Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	2197	4658
1901	3296	7922
1902	4347	8692
1903	3010	5941
1904	2134	4629
1905	471	1124
1906	2691	5953
1907	2404	7081
1908	2427	5516
1909	2590	5853
1910	2501	5508
1911	2191	5201

UNITED KINGDOM.

Annual Production and Value of Crude Petroleum in the United Kingdom.

Year.	Quantity.	Value.
	Tons.	£
1900	Nil.	..
1901	8	19
1902	25	60
1903	Nil.	..
1904	,,	..
1905	46	69
1906	10	15
1907	Nil.	..
1908	,,	..
1909	,,	..
1910	,,	..
1911	,,	..
1912	,,	..

[Table.

IMPORTS OF PETROLEUM INTO THE UNITED KINGDOM.

(Return by the Board of Customs and Excise.)

Countries whence consigned.	1908.		1909.		1910.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.	£	Gallons.	£	Gallons.	£
From Russia.	34,172,051	725,961	27,824,129	535,792	28,431,890	474,303
From United States.	245,801,410	4,538,494	268,532,909	4,190,779	251,818,363	3 746,404
From other Countries.	63,639,587	1,398,356	61,745,829	1,394,631	65,219,583	1,442,175
	343,613,048	6,662,811	358,102,867	6,121,202	345,469,836	5,662,882

Countries whence consigned.	1911.		1912.	
	Quantity.	Value.	Quantity.	Value.
	Gallons.	£	Gallons.	£
From Russia.	43,592,889	681,817	31,741,219	622,974
From United States.	240,209,563	3,374,592	260,156,798	4,170,377
From other Countries.	81.837,025	1,637,502	121.435,341	2,548,338
	365,639,477	5,693,911	413,333,358	7,341,689

BARBADOS.

No figures as to the production obtained from the existing petroleum wells are apparently available.

TRINIDAD.

The production of petroleum for the year ended 31st March 1911, was 4,378,942 gallons, valued at £18,070; and for the year ended March 1912, was 9,985,748 gallons, valued at £39,665.

NEWFOUNDLAND.

With the exception that 700 barrels of crude oil, valued at £233, were produced in 1904, no statistical evidence of the production of petroleum in the island is available.

NEW ZEALAND.

The first bonus of £2500 for the production of 250,000 gallons of oil has been received by the Taranaki Petroleum Company, that company having obtained 266,392 gallons of crude petroleum up to 3rd May 1911.

EGYPT.

Production of Crude Petroleum.

Year.	Quantity.
	Imperial Gallons.
1910, 1911 . . .	750,000
1912 . . .	7,260,000

270·5 gallons may be considered as equivalent to 1 ton.

WORLD'S PRODUCTION, 1910.*

(REDWOOD AND EASTLAKE.)

Country.	Quantity. Metric Tons.		Percentage of Total.
United States—			
Appalachian field	3,585,677		
Lima-Indiana field	967,182		
Illinois	4,419,115		
Mid-Continent field	7,862,115		
Gulf	1,324,290		
California	9,734,741		
Other fields	47,845		
		27,940,965	63·517
Russia		9,599,304	21·822
Galicia		1,762,560	4·007
Eastern Archipelago		1,435,240	3·263
Rumania		1,352,407	3·074
British India		808,794	1·839
Mexico		444,373	1·010
Japan	256,536		
Formosa	485		
		257,021	0·584
Peru		177,347	0·403
Germany		145,168	0·330
Canada		43,129	0·098
Italy		7,069	0·016
Hungary		2,501	0·006
Egypt		1,690†	0·004
Other countries		12,000†	0·027
Total		43,989,568	100·000

* It will be found that the figures for this year differ slightly from those given in *Petroleum*, 3rd edition, 1913. The reason is that statistics published for any one year are generally revised in the following year, and therefore it occasionally occurs that at the time of compilation accurate data are not available for the last year given. It may be taken that all figures relating to production in any year not covered by a succeeding year are subject to revision.

† Estimated.

WORLD'S PRODUCTION, 1911.

(Redwood and Eastlake.)

Country.		Quantity. Metric Tons.	Percentage of Total.
United States—			
Appalachian field	3,166,644		
Lima-Indiana field	830,821		
Illinois	4,175,605		
Mid-Continent field	8,789,038		
Gulf	1,557,008		
California	10,817,918		
Other fields	56,215		
		29,393,249	63·305
Russia		9,032,532	19·453
Mexico		1,873,547	4·035
Eastern Archipelago		1,624,301	3·498
Rumania		1,544,072	3·325
Galicia		1,462,940	3·151
British India		850,065	1·831
Japan	220,673		
Formosa	218		
		220,891	0·476
Peru		186,405	0·401
Germany		142,992	0·308
Canada		39,743	0·086
Italy		10,390	0·022
Hungary		3,000*	0·007
Other countries, including Egypt and Trinidad		47,277*	0·102
Total		46,431,404	100·000

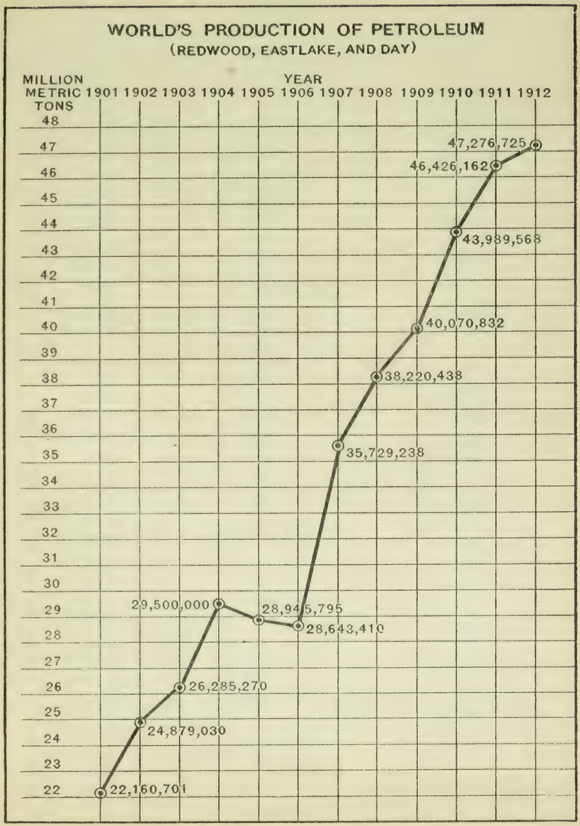
* Estimated.

WORLD'S PRODUCTION, 1912 AND 1913.

(DAVID T. DAY.)

Country.	1912. Quantity. Metric Tons.	1912. Percentage of Total.	1913. Quantity. Metric Tons.	1913. Percentage of Total.
United States	29,615,096	63·25	33,126,164	65·12
Russia	9,317,700	19·37	8,124,731	15·97
Mexico	2,207,762	4·71	3,426,172	6·74
Rumania	1,806,942	3·70	1,885,225	3·53
Dutch East Indies	1,478,132	3·09	1,534,223	3·14
Galicia	1,187,007	2·43	1,087,286	2·05
India	989,801	2·03	1,000,000	1·98
Japan	222,854	0·48	258,934	0·51
Peru	233,486	0·50	247,647	0·49
Germany	140,000*	0·28	132,769	0·27
Canada	32,612	0·07	30,410	0·06
Italy	12,000*	0·02	7,000	0·01
Other countries	33,333	0·07	69,015	0·13
Total	47,276,725	100·00	50,929,576	100·00

* Estimated.


WORLD'S PRODUCTION OF PETROLEUM
(REDWOOD, EASTLAKE, AND DAY)
MILLION METRIC TONS
YEAR
1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
22,160,701
24,879,030
26,285,270
29,500,000
28,945,795
28,643,410
35,729,238
38,220,438
40,070,832
43,989,568
46,426,162
47,276,725

ASPHALT.

AUSTRIA.

Quantity and Value of Asphalt Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	887	1999
1901	541	1611
1902	897	1695
1903	1273	2248
1904	1434	2892
1905	4363	2730
1906	2840	2562
1907	3858	3482
1908	3695	2864
1909	2975	2555
1910	1066	1795
1911	1740	3241

BARBADOS.

Quantity and Value of Asphalt ("Manjak") Exported.

Year.	Quantity.	Value.
	Tons.	£
1900	1120	6162
1901	1044	9394
1902	868	7817
1903	650	6508
1904	501	5012
1905	929	9292
1906	782	7820
1907	693	6930
1908	430	4304
1909	342	2492
1910	174	1306
1911	164	1568

COLOMBIA.

Since 1903 a deposit of asphalt has been worked near Chaparral, Tolima, and about 2000 tons have been shipped per annum.

CUBA.

Quantity and Value of Asphalt Exported.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	Not stated.	..
1901	,,	..
1902	,,	..
1903	4,790	7,111
1904	8,926	24,493
1905	10,142	17,981
1906	5,186	5,467
1907	5,054	7,725
1908	6,237	6,488
1909	10,796	9,914
1910	2,105	2,812
1911	3,300	4,506

GERMAN EMPIRE.

Quantity and Value of Asphalt Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	89,685	32,000
1901	90,193	33,750
1902	88,374	30,200
1903	87,454	40,600
1904	91,736	44,550
1905	103,006	49,500
1906	117,412	55,200
1907	126,649	54,350
1908	89,009	38,700
1909	77,537	36,350
1910	81,208	31,350
1911	81,902	32,550

HUNGARY.

QUANTITY AND VALUE OF ASPHALT PRODUCED.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	2900	12,698
1901	2878	12,573
1902	2774	12,173
1903	2422	10,603
1904	2221	9,492
1905	173	791
1906	4111	17,902
1907	3920	16,319
1908	4819	20,060
1909	5054	21,044
1910	4994	20,747
1911	3861	22,014

ITALY.

QUANTITY AND VALUE OF ASPHALT, ETC., PRODUCED.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	100,775	53,595
1901	104,111	52,352
1902	64,245	30,366
1903	89,690	49,333
1904	111,900	63,829
1905	107,014	61,255
1906	131,339	71,905
1907	161,640	90,828
1908	134,694	75,682
1909	111,538	62,706
1910	162,669	93,067
1911	188,681	122,601

JAPAN.

Quantity and Value of Asphalt Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	Not stated.	..
1901	,,	..
1902	,,	..
1903	357	97
1904	544	145
1905	103	197
1906	39	734
1907	584	1117
1908	2404	5253
1909	4186	9289
1910	477	5960
1911	1260	2821

MEXICO.

Quantity and Value of Asphalt Exported.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	627	1,284
1901	634	1,341
1902	134	521
1903	175	721
1904	92 (*Sic* in "*Mines and Quarries.*" ? 920.)	1,331
1905	859	1,851
1906	1389	3,529
1907	4486	37,453
1908	5272	67,996
1909	5471	21,881
1910	2849	8,154
1911	8085	25,752

RUSSIA.

QUANTITY AND VALUE OF ASPHALT AND MINERAL PITCH PRODUCED IN RUSSIA.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	25,090	..
1901	26,622	..
1902	12,360	24,038
1903	25,577	42,467
1904	Not stated.	45,391
1905	21,221	36,258
1906	11,135	17,918
1907	12,809	20,899
1908	22,033	100,956

Later figures are not available.

SPAIN.

QUANTITY AND VALUE OF ASPHALT (ROCK) PRODUCED.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	4,193	1726
1901	3,956	1627
1902	6,301	2534
1903	6,277	2511
1904	3,761	1504
1905	5,725	2290
1906	7,794	3520
1907	8,219	3288
1908	12,373	4949
1909	5,283	2113

SWITZERLAND.

No definite figures of output relating to bituminous limestone, the asphalt rock of the Val de Travers, are apparently available. The production is about 25,000 tons per annum.

TRINIDAD.

Quantity and Value of Asphalt Produced.

	1903.	£.	1904.	£.	1905.	£.
	Tons.		Tons.		Tons.	
Asphalt, raw. . .	169,813	169,813	118,432	118,432	78,518	78,518
,, purified .	10,045	20,090	10,887	21,774	14,815	29,630
,, dried . .	2,484	3,312	3,722	4,962	7,245	9,660
Manjak . .	587	880	3,023	4,534	1,077	1,615

	1906.	£.	1907.	£.	1908.	£.
	Tons.		Tons.		Tons.	
Asphalt, raw . .	100,800	100,800	119,471	119,471		
,, purified .	27,171	54,342	24,246	32,328	125,994	75,012
,, dried . .	4,446	5,928	6,451	8,064		
Manjak . .	1,112	2,273	2,114	4,228	1,790	3,500

	1909–10.*	£.	1910–11.*	£.	1911–12*	£.
	Tons.		Tons.		Tons.	
Asphalt, raw . .						
,, purified .	141,924	86,928	138,244	81,311	184,753	93,772
,, dried . .						
Manjak . .	2,395	4,990	1,910	3,979	1,570	3,345

* Year ended 31st March.

TRINIDAD.

Quantity and Value of Asphalt Exported.

	1900.	£.	1901–2.*	£.
Liquid asphalt	2,052 gallons.	1,381	20,492 gallons.	169
Purified	16,847 tons.	33,695	15,648 tons.	31,296
Raw	141,905 ,,	142,384	127,747 ,,	127,748
Dried	..	..	589 ,,	589
	1902–3.*	**£.**	**1903–4.***	**£.**
Liquid asphalt	..	..	..	..
Purified	11,427 tons.	22,854	9,866 tons.	19,732
Raw	145,712 ,,	145,712	178,984 ,,	178,984
Dried	1,997 ,,	1,997	2,585 ,,	3,446

* Year ended 31st March.

TURKEY.

Quantity and Value of Asphalt Produced.

Year.	Quantity.	Value.
	Tons.	£
1901	3500	..
1902	Not stated.	..
1903	,,	..
1904	4700	£5 to £20 per ton.
1905	Not stated.	..
1906	,,	..
1907	,,	..
1908	5267 metric tons.*	11,875
1909	6039 ,, ,, *	15,000

* For the year ended March.

UNITED STATES OF AMERICA.

Quantity and Value of Asphaltum Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	49,355	85,764
1901	57,290	114,502
1902	95,671	157,742
1903	91,831	207,308
1904	74,002	186,338
1905	104,570	155,678
1906	125,246	264,957
1907	203,085	580,388
1908	168,177	387,861
1909	207,434	439,070
1910	235,943	632,457
1911	326,593	786,191

VENEZUELA.

Quantity and Value of Asphalt Exported.

Year.	Quantity.	Value.
	Metric Tons.	£
1902	4,049	15,543
1903	14,567	58,871
1904	13,519	54,076
1905	30,674	53,136
1906	20,080	20,189
1907	34,153	34,509
1908	22,774	40,852
1908–9*	28,620	29,161
1909–10*	33,840	37,000
1910–11*	38,627	39,270
1911–12*	56,514	62,670

* Year ended June.

OIL SHALE.

UNITED KINGDOM.

Output and Value of Oil Shale raised.

Year.	Quantity.	Value.
	Tons.	£
1900	2,282,221	627,844
1901	2,354,356	589,162
1902	2,107,534	500,804
1903	2,009,602	477,312
1904	2,333,062	544,346
1905	2,496,785	593,334
1906	2,546,522	657,928
1907	2,690,028	806,323
1908	2,892,039	795,257
1909	2,967,057	815,937
1910	3,130,280	860,827
1911	3,116,803	857,120
1912	3,184,826	765,730

FRANCE.

Quantity and Value of Bituminous Shale, Limestone, Etc., Produced.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	266,474	76,686
1901	249,655	74,598
1902	258,295	80,882
1903	243,295	72,528
1904	227,177	66,197
1905	191,509	66,853
1906	196,375	71,016
1907	177,074	65,769
1908	171,158	54,287
1909	169,054	55,309
1910	169,769	56,963
1911	169,697	54,248

AUSTRALIA—NEW SOUTH WALES.

Amount and Value of Oil Shale Produced in New South Wales.

Year.	Quantity.	Value.
	Tons.	£
1900	22,862	20,652
1901	54,774	41,489
1902	62,880	59,717
1903	34,776	28,617
1904	37,871	26,770
1905	38,226	21,247
1906	32,446	28,470
1907	47,331	32,055
1908	46,303	26,067
1909	48,718	23,617
1910	68,293	33,896
1911	75,104	36,980

NEW ZEALAND.

Quantity and Value of Oil Shale Produced.

Year.	Quantity.	Value.
	Tons.	£
1900	Not stated.	..
1901	12,048	6024
1902	2,338	1169
1903	36	18
1904	Nil.	..
1905	,,	..
1906	,,	..
1907	,,	..
1908	1	4
1909	Nil.	..
1910	,,	..
1911	,,	..

TASMANIA.

Quantity and Value of Oil Shale Produced.

Year.	Quantity.	Value.
	Tons.	£
1910	364	214
1911	500	250

SPAIN.

Oil shale is mined in Spain, but no statistical data are obtainable as to the quantity raised.

OZOKERITE.

AUSTRIA.

QUANTITY AND VALUE OF OZOKERITE PRODUCED IN GALICIA.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	2003	66,019
1901	2707	107,096
1902	2655	121,663
1903	2849	181,107
1904	3086	196,942
1905	2957	172,005
1906	2698	139,565
1907	2508	129,771
1908	2592	134,923
1909	2115	112,689
1910	2171	121,714
1911	1940	108,846

RUSSIA.

QUANTITY AND VALUE OF OZOKERITE PRODUCED.

Year.	Quantity.	Value.
	Metric Tons.	£
1900	Not stated.	..
1901	,,	..
1902	183	7336
1903	86	2141
1904	Not stated.	..
1905	,,	..
1906	223	4746
1907	498	Not stated.
1908	618	,,

NATURAL GAS.

UNITED KINGDOM.

QUANTITY AND VALUE OF NATURAL GAS OBTAINED AT HEATHFIELD, SUSSEX.

Year.	Quantity.	Value.
	Cubic Feet.	£
1900	Not stated.	..
1901	,,	..
1902	150,000	30
1903	972,460	194
1904	774,800	155
1905	Nil.	..
1906	,,	..
1907	,,	..
1908	,,	..
1909	236,800	Not stated.
1910	262,000	,,
1911	221,400	,,
1912	161,200	,,

ITALY.

PRODUCTION OF NATURAL GAS IN ITALY.

Year.	Quantity. Cubic Metres.
1903	2,255,596
1904	2,551,396
1905	3,092,000
1906	5,723,469
1907	5,710,000
1908	6,737,500
1909	8,268,000
1910	8,840,000
1911	9,021,000

RUSSIA.

Production of Natural Gas at Baku (Surakhany).

The amount of gas obtained and used as fuel was as follows :—

Year.	Million Cubic Metres.
1905	46·53
1906	96·30
1907	117·13
1908 (to June 1st)	27·92

About 1037 cubic metres of the gas are equal in fuel value to 1 metric ton of crude oil.

CANADA.

Value of Natural Gas Produced.

Year.	Value. £
1900	85,704
1901	69,755
1902	40,272
1903	41,550
1904	50,829
1905	77,992
1906	106,672
1907	167,472
1908	208,081
1909	248,020
1910	276,672
1911	394,043

NEW BRUNSWICK.

Production of Natural Gas in the Stony Creek Field, Albert County.

According to information furnished by Dr. J. A. L. Henderson, Director of the Maritime Oil-Fields, Limited, the production of this field, as represented by the amount of gas sold and that consumed by his Company, was as follows :—

Period.	Gas sold, Cubic Feet, in Moncton (City) and Hillsborough.	Gas consumed by Company, Cubic Feet (estimated).	Total Gas Consumption, Cubic Feet.
1909. July to end April 1912.	. .	42,000,000	42,000,000
1912. End April to 27th June.	16,498,000	4,000,000	20,498,000
July.	10,660,000	2,000,000	12,660,000
August.	13,235,000	2,000,000	15,235,000
September.	20,852,000	2,000,000	22,852,000
October.	25,441,000	2,000,000	27,441,000
November.	34,786,000	2,000,000	36,786,000
December.	51,244,000	2,257,000	53,501,000
1913.			
January.	90,531,000	2,074,000	92,605,000
February.	97,414,000	1,020,000	98,434,000
March.	83,771,000	2,071,000	85,842,000
Total.	444,432,000	63,422,000	507,854,000

UNITED STATES OF AMERICA.

Value of Natural Gas Produced.

Year.	Value.	
	$	£
1900	23,698,674	4,886,324
1901	27,066,077	5,580,634
1902	30,867,863	6,364,507
1903	35,807,860	7,383,065
1904	38,496,760	7,937,476
1905	41,562,855	8,569,661
1906	46,873,932	9,664,728
1907	54,222,399	11,386,061
1908	54,640,374	11,266,056
1909	63,206,941	13,032,297
1910	70,756,158	14,588,898
1911	..	15,221,259

DISTRIBUTION OF NATURAL GAS CONSUMED

State.	Producers.			Consumers.		Gas Consumed.	
						Domestic.	
	Reporting Gas Wells.	Reporting Gas from Oil Wells.	Total.	Domestic.	Industrial.	Quantity, M. Cubic Feet.	Cents per M. Cubic Feet.
Pennsylvania .	777	1581	2358	294,781	5,337	39,729,064	24·4
Ohio .	1534	641	2175	450,973	5,260	50,356,496	26·8
Kansas * .	199	39	238	182,657	1,160	23,863,178	20·6
West Virginia †	183	178	361	70,853	1,907	12,089,067	16·4
New York .	282	373	655	92,958	570	11,290,837	27·2
Oklahoma .	131	317	448	32,907	1,527	4,393,368	16·4
Indiana .	1010	112	1122	40,565	369	4,666,554	30·2
Kentucky .	38	22	60	25,639	137	1,946,528	26·5
Illinois .	194	210	404	8,458	518	1,270,421	19·5
Texas .	17	15	32	5,035	130		
Louisiana .	11	..	11	4,034	164	771,077	27·1
Alabama .	5	..	5	500	1		
California .	35	96	131	7,612	104	224,780	90·4
Arkansas .	4	..	4	4,310	45		
Colorado .	3	9	12	906	10	561,296	25·2
Wyoming .	4	1	5	233	6		
South Dakota	35	..	35	374	6	16,964	71·7
Missouri .	29	2	31	401	5	36,533	19·5
North Dakota	16	..	16	231	2	4,750	41·6
Tennessee .	5	..	5	2	1	600	25·0
Michigan .	4	..	4	4	..	510	50·0
Iowa .	6	..	6	4	..	100	50·0
Oregon .	1	..	1	1	..	100	50·0
Total .	4523	3596	8119	1,223,438	17,259	151,222,223	24·23

* Includes the consumption of gas piped from Kansas to Missouri.

IN THE UNITED STATES IN 1909.

Gas Consumed.						
Domestic.	Industrial.			Total.		
Value. $	Quantity, M. Cubic Feet.	Cents per M. Cubic Feet.	Value. $	Quantity, M. Cubic Feet.	Cents per M. Cubic Feet.	Value. $
9,691,804	123,927,081	9·6	11,947,298	163,656,145	13·22	21,639,102
13,503,091	47,510,684	11·3	5,381,221	97,867,180	19·30	18,884,312
4,923,702	54,024,280	6·4	3,432,374	77,887,458	10·73	8,356,076
1,985,232	63,135,580	5·1	3,197,822	75,224,647	6·89	5,183,054
3,068,150	1,914,145	11·4	218,373	13,204,982	24·89	3,286,523
721,477	20,830,566	4·9	1,022,486	25,223,934	6·91	1,743,963
1,407,313	1,492,475	14·0	209,590	6,159,029	26·25	1,616,903
515,941	2,248,539	8·0	179,636	4,195,067	16·58	695,577
248,318	7,202,439	5·5	396,083	8,472,860	7·61	644,401
208,774	3,594,258	6·8	244,479	4,365,335	10·38	453,253
203,156	2,098,967	11·6	243,777	2,323,747	19·23	446,933
141,458	1,480,753	5·8	85,467	2,042,049	11·11	226,925
12,164	5,800	69·0	4,000	22,764	71·00	16,164
7,129	12,584	23·0	2,896	49,117	20·41	10,025
1,975	4,200	25·0	1,050	8,950	33·80	3,025
150	1,600	12·5	200	2,200	15·91	350
255	..	..	..	510	50·00	255
50	..	..	..	100	50·00	50
50	..	..	..	100	50·00	50
36,640,189	329,483,951	8·06	26,566,752	480,706,174	13·15	63,206,941

† Includes the consumption of gas piped from West Virginia to Maryland.

DISTRIBUTION OF NATURAL GAS CONSUMED

State.	Producers.			Consumers.		Gas Consumed.	
						Domestic.	
	Reporting Gas Wells.	Reporting Gas from Oil Wells.	Total.	Domestic.	Industrial.	Quantity, M. Cubic Feet.	Cents per M. Cubic Feet.
Pennsylvania .	819	1584	2403	321,430	5,591	43,404,565	25·3
Ohio .. .	1630	638	2268	475,505	3,804	60,539,597	25·0
Kansas * .	204	38	242	185,972	1,228	23,792,122	21·9
West Virginia †	241	189	430	86,778	2,823	13,637,059	17·4
New York .	273	375	648	106,538	1,058	12,247,528	29·7
Oklahoma ‡ .	168	343	511	38,978	2,059	5,397,284	16·9
Indiana § .	1027	117	1144	36,054	282	4,315,403	30·1
Kentucky .	47	21	68	27,961	112	2,574,352	27·9
Illinois ‖ .	207	227	434	10,109	479	1,266,057	21·9
Louisiana .	21	..	21	8,547	320		
Texas .	19	20	39	14,719	133	1,616,332	31·8
Alabama .	7	..	7	95	6		
California .	30	124	154	8,292	217	245,738	79·2
Arkansas .	9	..	9	4,422	121		
Colorado .	5	11	16	1,051	13	722,895	24·8
Wyoming .	5	2	7	353	4		
South Dakota	37	..	37	371	8	23,074	77·6
Missouri .	33	1	34	322	5	22,704	28·6
North Dakota	14	..	14	212	3	16,620	39·8
Michigan .	8	1	9	7	1	420	100·0
Tennessee .	5	..	5	2	..	1,200	25·0
Iowa . .	5	..	5	4	..	80	50·0
Total .	4814	3691	8505	1,327,722	18,267	169,823,030	24·4

* Includes the consumption of gas piped from Kansas to Missouri.
† Includes the consumption of gas piped from West Virginia to Maryland.
‡ Includes the consumption of gas piped from Oklahoma to Missouri.

IN THE UNITED STATES IN 1910.

Gas Consumed.						
Domestic.	Industrial.			Total.		
Value. $	Quantity. M. Cubic Feet.	Cents per M. Cubic Feet.	Value. $	Quantity. M. Cubic Feet.	Cents per M. Cubic Feet.	Value. $
10.972,250	125,470,994	10·3	12,962,441	168,875,559	14·17	23,934,691
15,145,537	47,535,063	12·8	6,065,428	108,074,660	19·63	21,210,965
5,202,914	58,137,618	6·8	3,960,949	81,929,740	11·19	9,163.863
2,377,276	63,430,697	5·1	3,240,634	77,067,756	7·29	5,617,910
3,646,180	1,947,276	16·3	317,692	14,194,804	27·92	3,963,872
912,958	22,482,779	5·2	1,169,250	27,880,063	7·47	2,082,208
1,299,247	1,444,849	12·1	174,156	5,760,252	25·58	1,473,403
718,657	2,384,242	8·0	189,636	4,958,594	18·32	908,293
278,377	5,457,229	6·1	335,265	6,723,286	9·13	613,642
514,782	6,494,170	6·8	441,901	8,110,502	11·80	956,683
194,631	2,518,769	11·2	282,066	2,764,507	17·24	476,697
179,324	1,982,053	6·1	121,827	2,704,948	11·13	301,151
17,899	20,300	69·5	14,100	43,374	73·77	31,999
6,501	24,440	25·0	6,110	47,144	26·75	12,611
6,610	1,000	40·0	400	17,620	39·78	7,010
420	800	50·0	400	1,220	67·21	820
300	..	..	..	1,200	25·00	300
40	..	..	..	80	50·00	40
41,473,903	339,332,279	8·63	29,282,255	509,155,309	13·90	70,756,158

§ Includes the consumption of gas piped from Indiana to Chicago, Ill.
|| Includes the consumption of gas piped from Illinois to Vincennes, Ind.

PRODUCTION OF GASOLINE FROM NATURAL GAS IN THE UNITED STATES IN 1911, BY STATES.

State.	Number of Operators.	Plants.		Gasoline Produced.			Gas Used.		Average Yield in Gasoline
		Number.	Daily capacity.	Quantity.	Value.	Value per Gallon.	Estimated Quantity.	Value.	
			Gallons.	Gallons.	$		Cubic Feet.	$	Gallons.
West Virginia	46	71	16,694	3,615,251	258,619	7·15	1,237,928,600	74,876	2·92
Ohio.	27	40	6,579	1,723,899	122,203	7·09	484,644,000	38,772	3·56
Pennsylvania.	43	50	5,669	1,467,043	109,649	7·47	526,152,663	52,615	2·79
Oklahoma.	8	8	4,800	388,058	20,975	5·40	144,629,000	4,378	2·68
California. Colorado. Illinois. New York.	7	7	3,358	231,588	20,258	8·75	82,343,000	6,320	2·81
Total	131	176	37,100	7,425,839	531,704	7·16	2,475,697,263	176,961	3·00

YIELD OF NATURAL GAS IN GASOLINE IN PENNSYLVANIA IN 1911.

County.			Yield of Gas in Gasoline per 1000 Cubic Feet.	Average Gravity (Baumé) of Gasoline as Produced and before Blending.
Location of Plant.	Number of Operators.	Number of Plants.		
			Gallons.	
Allegheny .	2	4		
Armstrong .	1	1	2·4–6	86°– 87° B.
Washington .	1	2		
Butler .	16	19	1·0–6	75°– 93° B.
Forest .	1	1		
McKean .	2	2	2·0–6	75°– 90° B.
Venago .	1	1		
Warren .	19	20	1·0–3	76°–100° B.
Total .	43	50		

YIELD OF NATURAL GAS IN GASOLINE IN WEST VIRGINIA IN 1911.

County.			Yield of Gas in Gasoline per 1000 Cubic Feet	Average Gravity (Baumé) of Gasoline as Produced and before Blending.
Location of Plant.	Number of Operators.	Number of Plants.		
			Gallons.	
Brooke .	4	5	1·5–8·0	87·0°–94° B.
Calhoun .	1	1		
Hancock .	1	1		
Harrison .	1	2	1·0–5·0	83·2°–92° B.
Marion .	1	1		
Marshall .	1	1		
Pleasants .	10	13	2·0–2·5	75°–91° B.
Ritchie .	5	7	1·5–4·6	83·2°–96° B.
Tyler . .	16	34	1·5–9·0	79°–95° B.
Wetzel .	2	2		
Wirt . .	1	1	1·5–3·0	80·0°–89° B.
Wood . .	3	3	1·0–4·5	87·0°–89° B.
Total .	46	71		

YIELD OF NATURAL GAS IN GASOLINE IN OHIO IN 1911.

County.			Yield of Gas in Gasoline per 1000 Cubic Feet.	Average Gravity (Baumé) of Gasoline as Produced and before Blending.
Location of Plant.	Number of Operators.	Number of Plants.		
			Gallons.	
Athens .	1	1		
Fairfield .	1	1		
Jefferson .	1	1	2·0–5	88°–92° B.
Wood . .	1	1		
Columbiana .	2	2		
Morgan .	2	2	2·0–5	80°–91° B.
Monroe .	7	17	0·5–9	70°–95° B.
Washington .	12	14	1·0–9	80°–95° B.
Total .	27	40		

HUNGARY.

No statistics are at present available as to the production of natural gas. From measurements made during March and April 1910 by Messrs Böhm and Szmolka, a well drilled at Kissarmas yielded the enormous quantity of 30,513,525 cubic feet per 24 hours.

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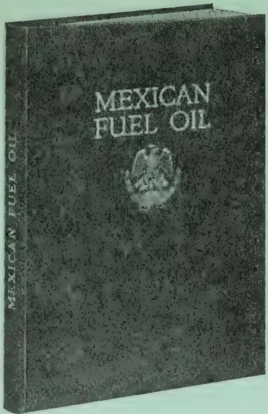

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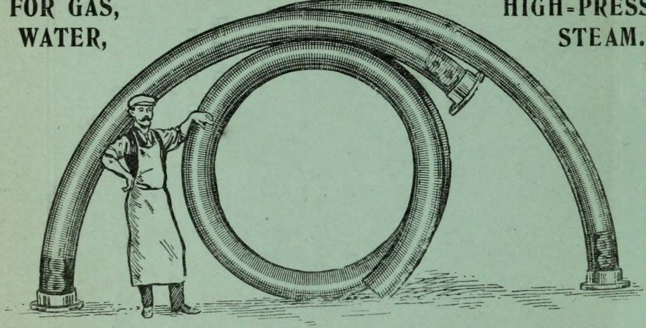

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